SOLAR ENERGY DESIGN IMPROVEMENT; A METHODOLOGY FOR HYDRONIC FLAT PLATE COLLECTOR SYSTEMS

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THESIS

SOLAR ENERGY DESIGN IMPROVEMENT:
A METHODOLOGY
FOR HYDRONIC FLAT PLATE COLLECTOR SYSTEMS

by

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Eight parameters have been included as independent design variables. The design variables included collector area, collector

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Initial system trials indicate complete stability with minimal constraint activations. Based on the results of approximately fifty design experiments using SOLOAD-1, new findings concerning optimum collector tilt angle and an incariant optimum collector flow factor are suggested.

Solar Energy Design Improvement:
A Methodology
For Hydronic Flat Plate Collector Systems

by

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Eight parameters have been included as independent design variables. The design variables included collector area, collector tile angle, collector and storage fluid stream velocities, and collector to storage heat exchanger dimensions. The procedure includes an accounting for economic parameters as an intimate part of the design process. The resulting methodology has been used for the design of solar energy systems which would use shelf item collectors for the purposes of determining the optimum design variable vector for a given situation. The methodology could also be used on a limited basis for collector design optimization by exploring the effects of changing selected collector parameters on system performance. The methodology is coded in the FORTRAN computer language under the name SOLOAD-1 (SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN).

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TABLE OF CONTENTS

I. INTRODUCTION ---------------------------------- 12

A. BACKGROUND ---------------------------------- 12

B. SCOPE ---------------------------------- 13

C. OBJECTIVES ---------------------------------- 14

II. SYSTEM MODEL ---------------------------------- 16

A. SYSTEM DESCRIPTION ---------------------------------- 16

B. ENERGY BALANCE ---------------------------------- 16

C. ECONOMIC ANALYSIS ---------------------------------- 17

D. THE OBJECTIVE FUNCTION ---------------------------------- 18

III. SYSTEM OF EQUATIONS ---------------------------------- 20

A. GENERAL SUMMARY ---------------------------------- 20

B. SPECIFIC PARAMETERS ---------------------------------- 20

1. Annual Energy Load, Q_L ---------------------------------- 20

2. Annual Solar Energy Load Fraction, $\bar{f}$ --- 21

3. Fuel Cost Parameters ---------------------------------- 27

4. System Cost Parameters ---------------------------------- 27

IV. NUMERICAL OPTIMIZATION ---------------------------------- 30

A. SIMPLE OPTIMIZATION ---------------------------------- 30

B. THE COPES/CONMIN SYSTEM ---------------------------------- 31

1. Terminology ---------------------------------- 31

2. Methodology ---------------------------------- 33

V. SOLOAD-1 SYSTEM ---------------------------------- 37

VI. RESULTS ---------------------------------- 38

VII. CONCLUSIONS ---------------------------------- 40

VIII. RECOMMENDATIONS ---------------------------------- 41

IX. FIGURES --- 43

APPENDIX A: Subroutine Analiz Summary ---------------- 47

APPENDIX B: SOLOAD-1 Computer Program ---------------- 48

APPENDIX C: SOLOAD-1 Data Files ---------------------- 70

APPENDIX D: Experiment Report Summaries -------------- 76

APPENDIX E: Potential Correlation for Optimum
Collector Flow Rate ----------------------- 228

BIBLIOGRAPHY -- 231

INITIAL DISTRIBUTION LIST ----------------------------- 233

LIST OF FIGURES

1. System Model -------------------------------- 43

2. Typical $\bar{f}$ vs A_c ---------------------------- 44

3. Typical Collector Efficiency Curves ------- 45

4. SOLOAD - COPES/CONMIN Interface ----------- 46

NOMENCLATURE

English Letter Symbols

A_r - load heat transfer surface area, ft^2

A_c - collector area, ft_c^2

C - capacity, Btu/hr F

C_c - collector cost, $\$/ft_c^2$

C_f - fuel cost, \$/Btu

C_i - system initial cost per unit collector area, $\$/ft_c^2$

C_I - system installation cost per unit collector area, $\$/ft_c^2$

C_L - system lifecycle cost, \$

C_{pp} - system annual pumping power cost per unit collector area, $\$/ft_c^2$ yr

C_s - system lifecycle cost per unit collector area, $\$/ft_c^2$

C_{tk} - storage tank cost per unit collector area, $\$/ft_c^2$

C_v - lifecycle operation and maintenance cost per unit collector area, $\$/ft_c^2$

C_x - collector to storage heat exchanger cost per unit collector area, $\$/ft_c^2$

c_p - specific heat, Bty/lb F

d - monthly diffuse solar insolation on a horizontal surface, Btu/ft^2 mon

d_i - collector loop inner diameter, ft

d_o - collector loop out diameter, ft

d_{xi} - heat exchanger annulus inner diameter, ft

D_{in} - value of the solar energy, \$

D_{out} - lifecycle cost, $

$D_{storage}$ - net savings, $

$\bar{f}$ - annual fraction of the energy load provided by solar energy

f_i - monthly fraction of the energy load provided by solar energy

F' - collector efficiency factor

F'' - collector flow factor

F_m - system maintenance cost factor

F_r - collector heat removal factor

F_r' - collector to heat exchanger efficiency factor

F_i' - present worth factor

$F(\bar{X})$ - objective function

G - collector loop flow rate per unit collector area, gpm/ft_c^2

$G_j(\bar{X})$ - inequality constraint

I - solar insolation on a horizontal surface, Btu/hr ft^2

I_o - extraterrestrial solar insolation on a horizontal surface, Btu/hr ft^2

I_t - solar insolation on a surface tilted towards the equator, Btu/hr ft^2

ICALC - control flag for COPES

L - heat exchanger length

$\dot{m}$ - mass flow rate, lb/hr

NCON - number of constraints

NDV - number of design variables

NPV - net present value, $

q - iteration number

Q_e - rate of utilization of auxiliary energy, Btu/hr

Q_{hex} - rate of energy transfer at the heat exchanger, Btu/hr

Q_L - rate of energy transfer from the load to the environment, Btu/hr

Q_u - rate of useful energy collection, Btu/hr

R - collector tilt correction factor

R_d - ratio of monthly diffuse insolation on a tilted surface to the monthly direct insolation on a horizontal surface

$\bar{R}_D$ - average ratio of monthly direct insolation on a tilted surface to the monthly direct insolation on a horizontal surface

R_ρ - ratio of monthly reflected radiation on a tilted surface to the monthly total radiation on a horizontal surface

s - collector tilt angle, deg

$\bar{S}$ - search direction

T_a - ambient climatic temperature, F

T_i - collector inlet temperature, F

T_o - collector outlet temperature, F

T_s - storage tank outlet temperature, F

U_L - collector loss coefficient, Btu/hr ft^2 F

v_c - collector loop flow velocity, ft/hr

v_s - storage loop flow velocity, ft/hr

VLB_i - lower side constraint for i-th design variable

VUB_i - upper side constraint for i-th design variable

W_p - rate of work energy used to maintain system flow, Btu/hr

$\bar{X}$ - vector of deisgn variables

Greek Letter Symbols

α - absorptance of the collector absorber surface

α^* - move parameter in optimization problem

δ - declination angle of the earth, deg

ε - heat exchanger effectiveness

ζ_1 - 1st collector flow parameter

ζ_2 - 2nd collector flow parameter

η - collector efficiency

κ^* - unique flow factor (optimum F")

κ^{**} - flow rate proportionality constant, gpm hr F/Btu

ρ - ground reflectivity

τ - transmittance of collector covers

ϕ - latitude angle, deg

ω_s - sunrise hour angle for horizontal surface, deg

ω_s' - sunrise hour angle for tilted surface, deg

I. INTRODUCTION

A. BACKGROUND

The control and utilization of energy has become the major issue of this decade: the energy crises. The inflation rate of energy costs and particularly fossil fuel costs has the spector of uncontrollability as this decade comes to a close. Reference [1] reports a 30% increase in the price of oil in 1978 alone. Reports from the media in early September 1979 indicate the price of home heating oil has incresed 70% since the 1978 heating season. The crisis center appears to be an emerging realization that the supply of available energy is in fact exhaustible. This realization has spread from a few to the masses; unquestionably the fruit of the Organization of Petroleum Exporting Countries.

In June of 1979, President Carter proposed to the Congress an energy strategy whereby solar energy would be providing 20% of the Nation's energy by the year 2000. For the purposes of domestic hot water (DHW) and residential space heating this goal is technically achievable. The basic solar energy technical theory is well documented by Duffie and Beckman [2] and Kreith and Kreider [3] and the technology is continually being updated in the Solar Energy Journal [4]. The increased effort in solar energy research work is in clear evidence as the documentation in this journal appears to be on an exponential rise.

The treatment of solar energy system performance is typically a determination of the fraction of a given heat load which is provided by solar energy. This fraction, $\bar{f}$, is a nonlinear function of many system variables but typically increases in a monotonic fashion as a function of collector area. To simply seek maximum $\bar{f}$ and maximum collection of energy in an unconstrained fashion can result in extreme initial system costs. Accordingly, in order to assure a proper balance, technical performance and cost should be considered throughout the design process and economics should become an intimate part of the technical design problem; not an after thought at the end of system design.

The economic ingredient in the problem of solar energy system design has received little attention in the literature. In view of this there is little information in the literature on how to proceed with design improvement of a solar energy system. Accordingly, a broad objective for this work was to develop a solar energy system model including economic considerations and to seek system design improvement by using the resulting eco-technical model together with an optimization algorithm.

B. SCOPE

The conversion of solar energy into useful work covers a broad spectrum of collection schemes. These include thermal, photovoltaic, biological, wind, and ocean thermal energy conversion. Reference [5] is an excellent introductory

information source covering many methods of solar energy conversion and has become a classic. This thesis effort was limited to the thermal conversion of solar radiation for the purpose of generating low temperature heat. Since low temperatures are involved, only flat plate collectors were studied. Flat plat collectors can provide temperatures on the order of 200° F compared to concentrating collectors which can provide temperatures as high as 6700° F. The restrictions on temperature were chosen in keeping with availability analysis; matching the solar conversion system to its task. The task of providing high entropy, low quality DHW and space heating energy is matched with low availability (i.e., minimum utilization of available energy in high quality, low entropy forms such as oil, gas, and central power). The collector working fluid was restricted to water. Further, since the collection of solar energy is a stochastic process, only analysis for long term performance was studied. The analysis of the dynamic performance of specific systems in response to hourly climatic data has previously been conducted by Kline et al [6] and now forms the basis for long term analysis.

C. OBJECTIVE

The objective of this thesis was to develop methodologies for:

1. System synthesis including a determination of optimum system design variables including collector area, collector

tilt angle, heat exchanger sizes, and flow rates. This analysis would be based on using shelf item collectors characterized by performance parameters $F_r\tau\alpha$ and F_rU_L which have been determined by tests conducted in accordance with refs. [7 and 8].

2. Collector design optimization including a determination of the optimum combination of collector design variables such as materials and geometries; and which would yield the optimum system performance.

Fundamental to the effort was the utilization of:

1. COPES/CONMIN (Control Program for Engineering Synthesis with Constrained Function Minimization), a design improvement algorithm developed by Vanderplaats [9, 10, 11 and 12].

2. Standardized long term solar energy load fraction correslations (f - CHART) developed by Kline [6].

3. Economic considerations combined with technical analysis.

4. Long term climatic data obtained from (NOAA) National Oceanic and Atmospheric Administration [13].

II. SYSTEM MODEL

A. OVERALL SYSTEM DESCRIPTION

A schematic diagram of the solar heating system is shown in Figure 1. The system consists of four heat exchangers, a storage tank and associated system piping. The first heat exchanger is called the collector and is used to transform incident solar radiation into useful thermal energy. At the second heat exchanger the collected energy is transferred to the secondary loop and stored in the form of sensible energy in the storage tank. The sensible energy is transferred from storage to the loads via the third and fourth heat exchangers. Energy transfer is achieved via four forced convection flow loops. This model was further simplified by assuming total utilization of the energy stored in the tank and thereby eliminating the need to detail the DHW and space heating heat exchangers.

B. ENERGY BALANCE

The steady state power balance for the system is

$$Q_u + W_p + Q_e = Q_L \tag{1}$$

where,

Q_u = Useful rate of energy collection (Btu/hr)

W_p = Work energy utilized to maintain system flow

[illegible]

Q_e = Rate of utilization of auxiliary energy which is required in addition to solar energy in order to meet the DHW and space heating load

Q_L = Rate of energy loss by the system

For the purposes of this thesis, it has been assumed that W_p is a known or estimated parameter. Most analyses in the literature do not account for W_p since it is typically assumed to be a very small fraction of the energy required.

The percentage of the energy load which is supplied by solar energy is defined as:

$$\bar{f} = \frac{\sum_i Q_{u_i}}{\sum_i Q_{L_i}} \tag{2}$$

where the summation is taken over 12 monthly values.

$\bar{f}$ is a monotonically increasing function of collector area. No optimum $\bar{f}$ is evident. Figure 2 depicts a typical $\bar{f}$ distribution resulting from a design problem. Since initial costs are strongly dependent on collector area (see Section III), attempts to seek maximum $\bar{f}$ can result in very high initial system costs. At this point the motivation to include economic considerations as a part of the system design model become clear.

C. ECONOMIC ANALYSIS

The matter of economics has been treated as it evolved in this study: a simple common sense approach. This approach includes:

1. An economic equation which utilizes technical parameters obtained from mass, momentum and energy balance considerations together with economic parameters.

2. Standardization of the economic equation by characterization of all terms in present dollar values.

The economic analysis is similar to an energy balance. Considering the economic system as the monetary account of a consumer and the time period as the economic lifetime of the energy conversion equipment:

$$D_{in} = D_{out} + D_{storage} \qquad (3)$$

where,

D_{in} = The value if dollars of the energy produced by the equipment

D_{out} = The expense dollars to obtain, operate and maintain the equipment

$D_{storage}$ = The net savings

The rational consumer seeks maximum $D_{storage}$. This methodology is a simple capital budgeting technique and is contained in any standard reference in accounting or finance.

D. THE OBJECTIVE FUNCTION

Implicit in the use of the economic model is an assumption that the terms in the equation can be expressed as variables of the technical functions which have been defined by the physics of the engineering problem. For

the solar energy system utilized for domestic hot water and space heating the transformation is simple:

$$\text{Net Savings} = \text{Fuel Savings} - \text{System Costs}$$

This equation becomes the objective function by standardizing all dollar amounts to present values. The resulting equation is:

$$NPV = \bar{f}Q_L C_f F_i' - A_c C_s \tag{4}$$

where,

NPV = Net present value of the solar investment, \$

C_f = Fuel cost for the energy replaced by solar energy, \$/Btu

F_i' = Present worth factor which standardizes fuel savings during system life into present dollars, years

A_c = Collector area, ft_c^2

C_s = System lifecycle cost per unit collector area, \$/ft_c^2

The effort now proceeds to determining each of the above dependent parameters and to obtaining those combinations of these variables which will result in maximum values of NPV.

III. SYSTEM OF EQUATIONS

A. GENERAL

The objective function has been fully developed by examining each of its parameters individually. Completion of this development has resulted in a non linear function of eight independent design variables; a hypersurface in eight space. When formulated in this manner, the problem is clearly not amenable to analytical solution. In a very simple manner however the problem can be interfaced with the design improvement algorithm COPES/CONMIN (see Section IV). The primary contribution for this effort comes from Kline [6] who developed the f-chart correlations for determining monthly solar energy load fractions f_i. The annual load fraction $\bar{f}$ is then computed by a weighted average of the monthly values.

B. SPECIFIC PARAMETERS

1. Annual Energy Load, Q_L

The annual energy load consists of two basic ingredients; the DHW load and the space heating load. Assuming an average mean ground temperature the month to month DHW load was considered constant except for the variation due to month length. The methods for determining the space heating loads typically follow the ASHRAE manual, reference [14]. Reference [15] is recommended as a text for space heating load

computations. For the purposes of this study representative building loss parameters were used. Typical building conductance or $(UA)_r$ values of 30,000, 20,000 and 10,000 (Btu/deg F day) have been used based on a standard building of 1750 ft^2 of floor area, a heat transfer surface of 5000 ft^2 and building loss coefficients, U_r, of .25, .17, and .09 Btu/ft^2 hr F respectively. The conductance, UA, is the space heating load at design conditions which has been estimated in the manner of Ref. [14] and divided by the design temperature difference.

2. Annual Solar Energy Load Fraction, $\bar{f}$

$\bar{f}$ is a function of collector performance parameters, thermal physical properties of the working fluids, fluid flow rates, heat exchanger performance parameters, collector tilt angle, climatic conditions and latitude. The climatic conditions determine the load distribution (heating degree days), the solar energy flux distribution (insolation) and the environmental stress on the collector (ambient temperature).

a. Collector Performance

A determination of collector performance proceeds from the well known collector equation of Hottel and Whillier [16] which is the result of an energy balance on the collector:

$$Q_u = F_r U_L A_c (IR\tau\alpha - U_L(T_i - T_a)) \qquad (5)$$

where,

Q_u = Useful rate of energy collection (Btu/hr)

F_r = Collector heat removal factor (dimensionless)

U_L = Collector loss coefficient (Btu/hr ft^2 F)

A_c = Collector area (ft_c^2)

I = Solar insolation on a horizontal surface (Btu/hr ft^2)

R = Collector tilt correction factor (dimensionless)

τ = Transmittance of collector cover system (dimensionless)

α = Absorptivity of the collector absorber plate (dimensionless)

T_i = Collector fluid inlet temperature (F)

Ta = Climatic ambient temperature (F)

The analytical expressions for F_r and U_L are complex and result from a lengthy development which can be found in references [2 and 3]. The computation of F_r and U_L using these expressions is not necessary for system design analysis using shelf item collectors since the parameters $F_r U_L$ and $F_r \tau\alpha$ can be obtained from collector efficiency tests.

Collector efficiency is defined as:

$$\eta = \frac{Q_u/A_c}{IR} \tag{6}$$

Assuming that U_L is not sensitive to changes in the environment and combining equations (4) and (5) results in:

$$\eta = F_r \tau\alpha - F_r U_L((T_i - T_a) / IR) \tag{7}$$

Equation (7) is linear in the collector parameter $(T_i - T_a)/IR$ and forms the basis for determining collector performance. It is clear that the parameter F_rU_L is obtained from the slope and $F_r\tau\alpha$ is obtained from the intercept of equation (6). Some typical curves of collector efficiency are included in Figure 3.

Two standards have been developed for collector testing to measure collector performance, namely references [7] and [8]. The standards differ in the independent variables used in the performance characterization. Reference [7] the ASHRAE standard uses $T = T_i - T_a$; ref [8] the NBS standard uses $T = (T_i + T_o)/2$, where T_o is the collector outlet temperature. All collector performance test data used in this effort is based on the ASHRAE standard. All collector data used in this effort is based on actual collector tests conducted by NAVFAC and reported via ref [17].

b. Collector to Storage Coupling

The collector becomes coupled to the storage tank via the collector to storage heat exchanger following the method of de Winter [20]. It is assumed that the rate of energy transfer at the heat exchanger is equal to the rate of useful energy collection:

$$Q_{hex} = Q_u = \varepsilon(\dot{m}c_p)_{min}\,(T_o - T_s) \qquad (8)$$

where,

T_o = Maximum system temperature or collector outlet

T_s = Minimum system temperature or storage outlet.

Equations (5) and (8) are combined to eliminate T_i and T_o dependence to give:

$$Q_u = F_r'U_L(IR\tau\alpha - U_L(T_s - T_a)) \tag{9}$$

where,

$$F_r' = F_{hex}F_r \tag{10}$$

$$F_{hex} = \left\{1 + \frac{F_r U_L A_c}{(\dot{m}c_p)_c}\left[\frac{(\dot{m}c_p)_c}{\varepsilon(\dot{m}c_p)_{min}} - 1\right]\right\}^{-1} \tag{11}$$

c. Solar Insolation at Optimum Tilt Angle, I_t

The solar radiation intensity on a tilted surface is by definition:

$$I_t = IR \tag{12}$$

Solar insolation is typically measured and reported for a horizontal surface. Improvements in a solar collector installation are sought by tilting the collector to the optimum angle. The computation for

optimum angle is iterative for each design situation. Several rules of thumb have evolved:

(1) Collectors should be oriented at a slope of .9 times the latitude angle for maximum annual collection.

(2) For DHW systems where loads vary little during the year the best angle of tilt is equal to the latitude angle.

(3) The optimum collector tilt angle for least cost per Btu delivered for building heating is approximately the latitude angle plus 15 degrees.

The methodology for determining collector tilt angle used in this effort was as follows:

(1) Horizontal monthly data was obtained for 97 locations from NOAA in reference [13].

(2) An algorithm was developed to compute monthly horizontal extraterrestrial radiation intensities. This computation is a function of latitude, daily hour angles on horizontal and tilted surfaces, daily declination angle, and collector tilt angle. The azimuth angle was always chosen for a due south collector orientation.

(3) The methodology follows that of Liu and Jordan in reference [19]:

$$R = \left(1 - \frac{d}{I}\right)\overline{R}_D + \frac{d}{I} R_d + R_\rho \qquad (13)$$

$$\frac{d}{I} = 1.3903 - 4.0273\left(\frac{I}{I_o}\right) + 5.5315\left(\frac{I}{I_o}\right)^2 - 3.108\left(\frac{I}{I_o}\right)^3 \quad (14)$$

$$R_d = \frac{\omega_s' \sin(\phi - s)\sin\delta + \cos(\phi - s)\cos\delta\sin\omega_s'}{\omega_s \sin\phi\sin\delta + \cos\phi\cos\delta\sin\omega_s} \quad (15)$$

$$\omega_s' = \min[\cos^{-1}(-\tan(\phi - s)\tan\delta),\ \cos^{-1}(-\tan\phi\tan\delta)] \quad (16)$$

$$\omega_s = \cos^{-1}[-\tan\phi\tan\delta] \quad (17)$$

$$R_d = \frac{1}{2}(1 + \cos s) \quad (18)$$

$$R = \frac{1}{2}(1 - \cos s)\rho \quad (19)$$

where,

R = monthly slope correction factor

$\bar{R}_D$ = average ratio of monthly direct radiation on a tilted surface to monthly direct radiation on a horizontal surface

R_d = ratio of monthly diffuse radiation on a tilted surface to monthly diffuse radiation on a horizontal surface

R_ρ = ratio of monthly reflected radiation on a tilted surface to monthly total radiation on a horizontal surface

$\frac{d}{I}$ = ratio of monthly diffuse radiation on a horizontal surface to monthly total radiation on a horizontal surface

$\frac{I}{I_o}$ = ratio of monthly total radiation on a horizontal surface to monthly total extraterrestrial radiation on a horizontal surface

ω_s = sunrise hour angle on a horizontal surface

ω_s' = sunrise hour angle on a tilted surface

s = collector tilt angle

ϕ = latitude angle at collector site

δ = declination angle of the earth

ρ = ground reflectance for area adjacent to collector.

3. Fuel Cost Parameters

Fuel cost parameters included a selection from among 3 fuel types (i.e. oil, electricity, or gas), unit of issue cost, fuel heating value and efficiency of the auxiliary heating system. The SOLOAD-1 system allows complete freedom in the selection of these parameters. A typical set of fuel cost parameters used in a design experiment included:

Fuel:	Oil
Unit Cost:	.9 ($/Gal)
Heating value:	142,000 (Btu/Gal)
Efficiency:	.7
Resulting Fuel Cost:	C_f = $9.05 per 10^6 Btu

4. System Cost Parameters

System cost considerations typically include initial costs and life cycle costs for operation and maintenance. Detailed guidance for complete cost considerations is included in ref. [3]. Further, reference [20] contains guidance to be used in determining costs for US Navy installations. The following cost parameters were used in SOLOAD-1:

$$C_L = A_c C_s \tag{20}$$

where,

C_L = Total system life cycle cost

C_s = Total cost per square foot

$$C_s = C_i + C_v \tag{21}$$

$$C_i = C_c + C_I + C_{tk} + C_x \tag{22}$$

$$C_v = F_i'(C_i F_m + C_p) \tag{23}$$

where,

C_i = Initial system cost

C_v = Operation and maintenance costs

C_c = Collector cost

C_I = System installation cost

C_{tk} = Storage tank costs

C_x = Collector to storage heat exchanger costs

C_p = Pumping power costs

F_m = Maintenance cost factor

F_i' = Present worth factor

$$F_i' = \frac{1 - (1 + i')^{-N}}{i'} \tag{24}$$

where,

$$i' = \frac{i - j}{1 + j} \tag{25}$$

i = Discount rate

j = Fuel inflation rate

N = System life in years

It should be noted that F_i' occurs explicitly in the first term of the objective function and implicitly in the second term. It should also be noted that initial costs are not amortized in the SOLOAD-1 model.

IV. NUMERICAL OPTIMIZATION

A. SIMPLE OPTIMIZATION

Design problems typically seek the minimization or maximization of an appropriate parameter within a framework of constraint specifications. The parameter to be optimized may be a function of several design variables and is termed the objective function. Other parameters which may be separate functions of design variables must not exceed specified bounds for the design to be acceptable. These parameters are termed design constraints and are not to be confused with limits which may be set on design variables which are usually termed side constraints.

Engineering problems can be numerically coded for an analysis (once through) solution. The simplest scheme for optimization may consist of a series of loops through the computer code which may cycle many combinations of design variables. The combination of variables which provides the best design and which also satisfies the constraints is then considered optimum. This approach may be economical for a design problem with just a few design variables and short computer time requirements. A design problem with 3 design variables, ten values for each design variable, and one-tenth seconds central processing unit (CPU) time for each analysis would take a total of 100 seconds of CPU time. The solar energy optimization design problem as characterized

by the code developed by this thesis has a minimum of 8 design variables; each analysis of its objective function requires about 2 CPU seconds. Using the simple approach and assuming ten values for each design variable would result in a CPU time of 68 years for each design problem. Clearly, a more rational approach to optimization is necessary.

Vanderplaats [9] suggested that many special algorithms for numerical optimization have been proposed in recent years, but that in many cases unsuspecting practitioners find their particular optimization problem unsolved only after large amounts of time and effort are expended. This can occur usually because of inexperience by the practitioner in determining the limitations of specified algorithms. Vanderplaats [10, 11, and 12] has developed a FORTRAN coded algorithm capable of optimizing a very wide class of engineering problems. The system includes COPES (Control Program for Engineering Synthesis) and CONMIN (Constrained function Minimization). This optimization system is referred to as COPES/CONMIN.

B. THE COPES/CONMIN SYSTEM

1. Terminology

CONMIN is a FORTRAN program in subroutine form for the solution of linear or non-linear constrainted optimization problems. The user prepares an analysis program. The

program must be named SUBROUTINE ANALIZ. The process of computer aided design or of trade off studies with a minimum of man-machine interaction becomes fully automated via the COPES program. Three basic definitions are required:

Design Variables. Those parameters which the optimization program (CONMIN) is allowed to change in order to improve the design. Design variables appear only on the right hand side of equations in the analysis program (ANALIZ). Limits imposed on design variables are termed side constraints.

Objective Function. Usually the single parameter which is to be minimized or maximized during optimization. The objective function always occurs on the left side of the equation in the analysis program. (Refer to [12] for exceptions.) The equation defining the objective function may be linear or non-linear, implicit or explicit, but must be a function of the design variables to be meaningful.

Design Constraints. Any parameter which must not exceed specified bounds for the design to be acceptable. Constraint parameters always appear on the left side of the constraint function equations. Constraint functions may be linear or non-linear, implicit or explicit, but must be functions of the design variables.

Assuming that the optimization process requires the maximization of a particular objective function, the general optimization problem can be stated as:

a. Find: $\overline{X}$ which maximizes $f(\overline{X})$

b. Subject to:

(1) CONSTRAINT EQUATIONS $G_j(\overline{X}) \leq 0$, $j = 1$, NCON

(2) SIDE CONSTRAINTS $VLB_i \leq X_i \leq VUB_i$, $i = 1$, NDV

Where, $\overline{X} = \overline{X}(X_1, X_2, \ldots, X_n)$ is the vector of NDV design variables, $F(\overline{X})$ is the objective function and $G_j(\overline{X})$ are the set of NCON constraints. VLB_i and VUB_i are the lower and upper bounds respectively on each design variable.

2. Methodology

The solution process proceeds as follows:

a. The user prepares an analysis subroutine which defines $\overline{X}$, $F(\overline{X})$ and $G_j(\overline{X})$. This subroutine must be named ANALIZ. ANALIZ must have three segments; input, analysis and output keyed to COPES flags, ICALC = 1, 2, or 3 respectively.

b. The user prepares an input data file for COPES which includes a wide variety of system options, appropriate matching mechanisms between ANALIZ and CONMIN and the constraint boundaries.

c. Using the initial vector of design variables COPES obtains an initial solution from ANALIZ and subsequent solutions by updating $\overline{X}$ as determined by CONMIN. Any analysis solution which satisfies the constraint equations and the side constraints is a feasible design. If an analytical solution violates any of these constraints it is an infeasible design. The minimum feasible design is optimal.

The feasibility determination includes:

(1) If a constraint equation is violated (i.e., if $G_j(\overline{X}) > 0$) then the jth constraint is violated.

(2) If a constraint equation equality condition is met (i.e., if $G_j(\overline{X}) = 0$) then the jth constraint is active.

(3) If a constraint equation condition is met (i.e., if $G_j(\overline{X}) < 0$) then the constraint is inactive.

Note that CONMIN is designed to minimize objective functions; the process of maximizing an objective function is concerned with minimizing the negative of an objective function.

(4) Similarly, side constraints may be inactive or active but side constraints will never be violated in a particular analysis computation because they are specified limits not dependent variables which is the case for design constraints.

(5) All inequality conditions are represented by a band around the zero condition due to computer limitations in defining zero.

d. If the initial analysis solution is infeasible CONMIN moves towards a feasible solution by adjusting the design variables appropriately. The optimization process then proceeds in an iterative fashion as follows:

(1) The iterations are governed by the recursion relation:

$$\overline{X}^{q+1} = \overline{X}^{q} + \alpha^{*}\overline{S}^{q}$$

where,

- q = iteration number
- α^* = a scalar move parameter which defines the distance of travel in the direction of search
- $\overline{S}$ = direction of search

(2) $\overline{S}$ is determined such that $\overline{F}(\overline{X})$ will be minimized without violating any constraints. CONMIN calculates the gradient of $\overline{F}(\overline{X})$ by using finite difference techniques. Because no constraints are violated, the greatest improvement in $F(\overline{X})$ will be realized by moving in the direction of steepest ascent, the gradient of $F(\overline{X})$.

(3) Once the directive is known, the move parameter, α^*, which will allow the largest magnitude improvement in $F(X)$ is to be found. A one dimensioned search of the $\overline{S}$ direction is carried out until the best improvement number, α^*, is found.

(4) CONMIN utilizes methods other than the method of steepest descent in determining $\overline{S}$ particularly in the presence of active constraints. These methods include the method of conjugate directions developed by Fletcher and Reeves [21] and the method of feasible directions developed by Zoutendijh [22] and implemented by Vanderplaats and Moses [23].

e. CONMIN continues to iterate for an optimal design by computing successive $\overline{S}$ and α^* values always keeping within the defined constraints. If there is no relative or absolute change in $\overline{F}(\overline{X})$ for three successive iterations, the optimum is considered found.

V. SOLOAD-1 SYSTEM

A FORTRAN coded algorithm for the analysis of systems containing shelf item collectors has been developed. The algorithm has been named SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN (SOLOAD-1). The portions of the algorithm reserved for design optimization of collectors were not completed and have not been included in SOLOAD-1. The interface between SOLOAD-1 and COPES/CONMIN has been developed via the Control Program (CP-67) and the Cambridge Monitor System (CMS) a time-sharing system developed for the IBM System 360 Model 67. SOLOAD-1 includes:

A. Three executive programs to provide the interfaces among the system elements and to initiate design problems.

B. An analysis subroutine which includes the system of equations covered in Section III. A summary of the objective function, design variables, and design constraints is included in Appendix A.

C. Three auxiliary subroutines including a calendar data array, climatic data and user defined input parameters.

D. Data files for user input to SOLOAD-1 and COPES/CONMIN.

The interface among SOLOAD-1 system elements and COPES/CONMIN is shown in Figure 3. SOLOAD-1 programs and subroutines are included in Appendix B. Data files are included in Appendix C.

VI. RESULTS

A. GENERAL

The first objective of developing a methodology for the analysis of systems with previously defined collector design was achieved. The second objective of developing a methodology for optimizing the collector component design was not achieved. However, it appears that the potential exists for using the system analysis methodology to obtain improvements in collector design. For example, if cost data on various types of collector cover plates or collector absorber surfaces can be correlated with collector performance parameters, then the system model could be used for quick checks on collector design improvements.

B. VERIFICATION

A single design problem was selected and started using 10 different sets of the starting design variable vector. The same optimal design result within ± 0.5% was achieved for each run. This was the only actual verification deemed possible at this time due to lack of any known optimization data in the literature.

C. EXPERIMENTS

Approximately 50 design experiments were analyzed. Each problem was characterized by a unique identification number which could tie together the location, economic

environment, the collector, and the space heat transfer coefficient, UA, for the experiment. For each experiment an input parameter summary report and output parameter and results summary report was generated. These reports are included in Appendix D.

D. SPECIFIC RESULTS

1. Constraints

The only active design constraint in most experiments was the tube thickness in the collector loop at the heat exchanger. Some experiments resulted in no active design constraints. There were no active side constraints in any experiment.

2. Collector Flow Factor

The collector flow factor F" is defined as the ratio of the collector heat removal factor to the collector efficiency factor:

$$F'' = \frac{F_r}{F'}$$

The flow factor result obtained in all optimization experiments was the same. $F'' = .948 \pm .008$.

3. Collector Tilt Angle

Each experiment conducted for a particular geographical location resulted in the same collector tilt angle. However, experiments for different locations but the same latitude resulted in significantly different optimum collector tilt angles.

VII. CONCLUSIONS

A. The SOLOAD-1 system in conjunction with COPES/CONMIN appears to offer the potential for further improvement and potentially a valuable automated technique for solar energy system design.

B. The "rule of thumb" typically used for collector tilt angle optimization (i.e., latitude plus 15°) should be used with caution since preliminary results indicate a strong tendency for climatic dependency.

C. The uniqueness of the flow factor was suggested by the continued result of .948 ± .008 for each experiment. Pending confirmation by further testing it appears that a simple correlation for determining optimum collector loop flow rates may be available. Based on a flow factor of 0.948 the resulting correlation would be:

$$G = .01955\ F_r U_L \qquad (\text{gpm/ft}^2 \text{ of collector area})$$

This correlation is developed in Appendix E.

VIII. RECOMMENDATIONS

A. The basic model of SOLOAD-1 should be upgraded to include specific characterization instead of simple parameter selection and input for:

1. Pumping power in all four loops
2. Inclusion of the DHW heat exchanger
3. Inclusion of the space heat exchanger
4. Inclusion of building loss coefficients as a design variable.

B. Prior to any additional experiments with the present model, a complete survey of the industry should be conducted for collector parameters and costs. Following this survey, a series of experiments should be conducted in search of correaltions among collector performance parameters (i.e., $F_r(\tau\alpha)$ and F_rU_L), collector unit costs, and system performance.

C. A larger sample size should be used to verify the uniqueness of the optimum collector flow factor (F") as suggested by the results of 50 experiments.

D. The remainder of the NOAA climatic data bank (i.e., 67 more cities) should be included in SOLOAD-1. The optimum collector tilt angle could then be computed for the 97 NOAA regions.

E. The model should be upgraded to accommodate analysis for systems with air as the working fluid.

F. The model should be upgraded to accommodate amortization of the installation cost instead of just initial cash payment.

IX. FIGURES

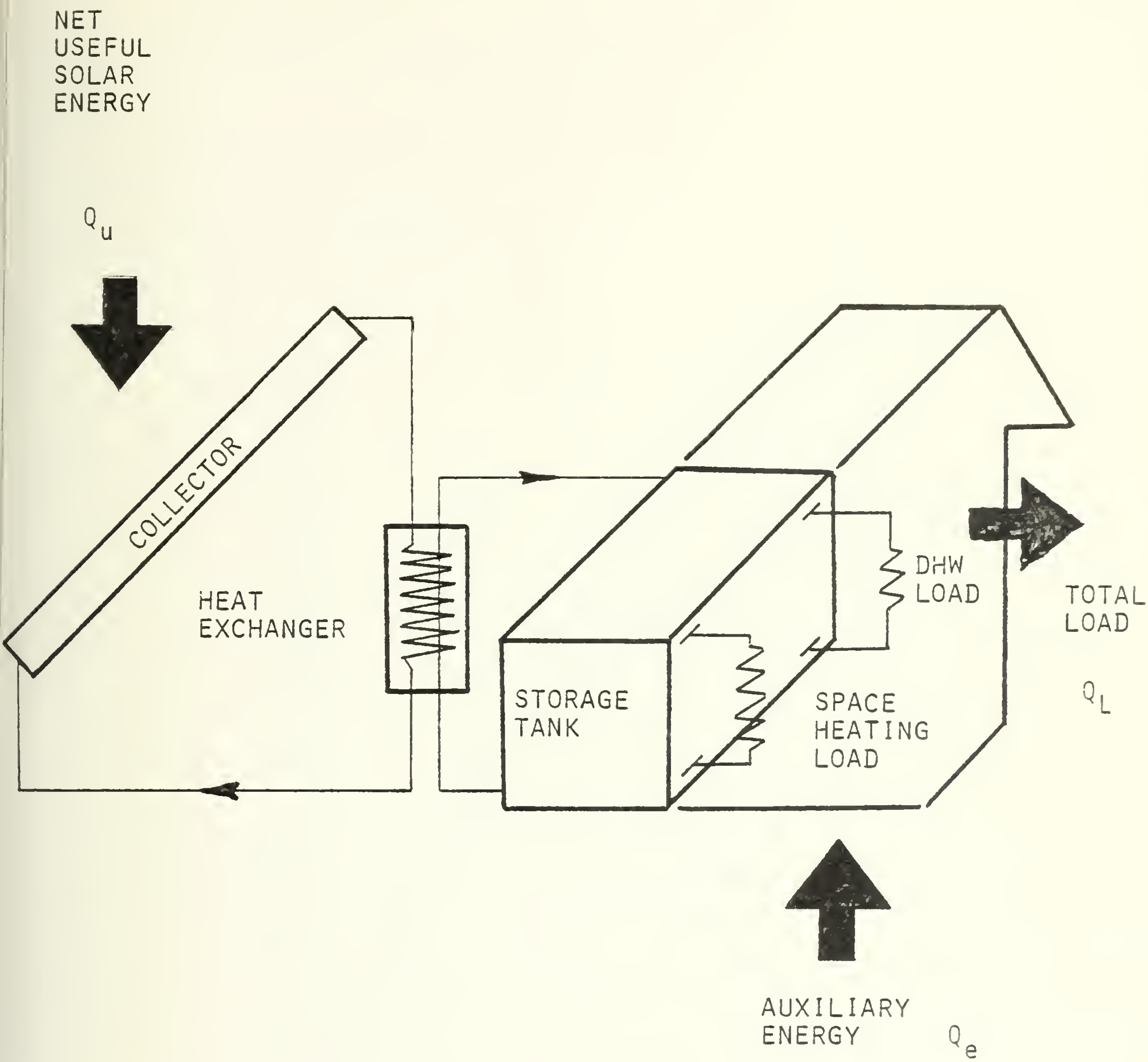

FIGURE 1 System Model

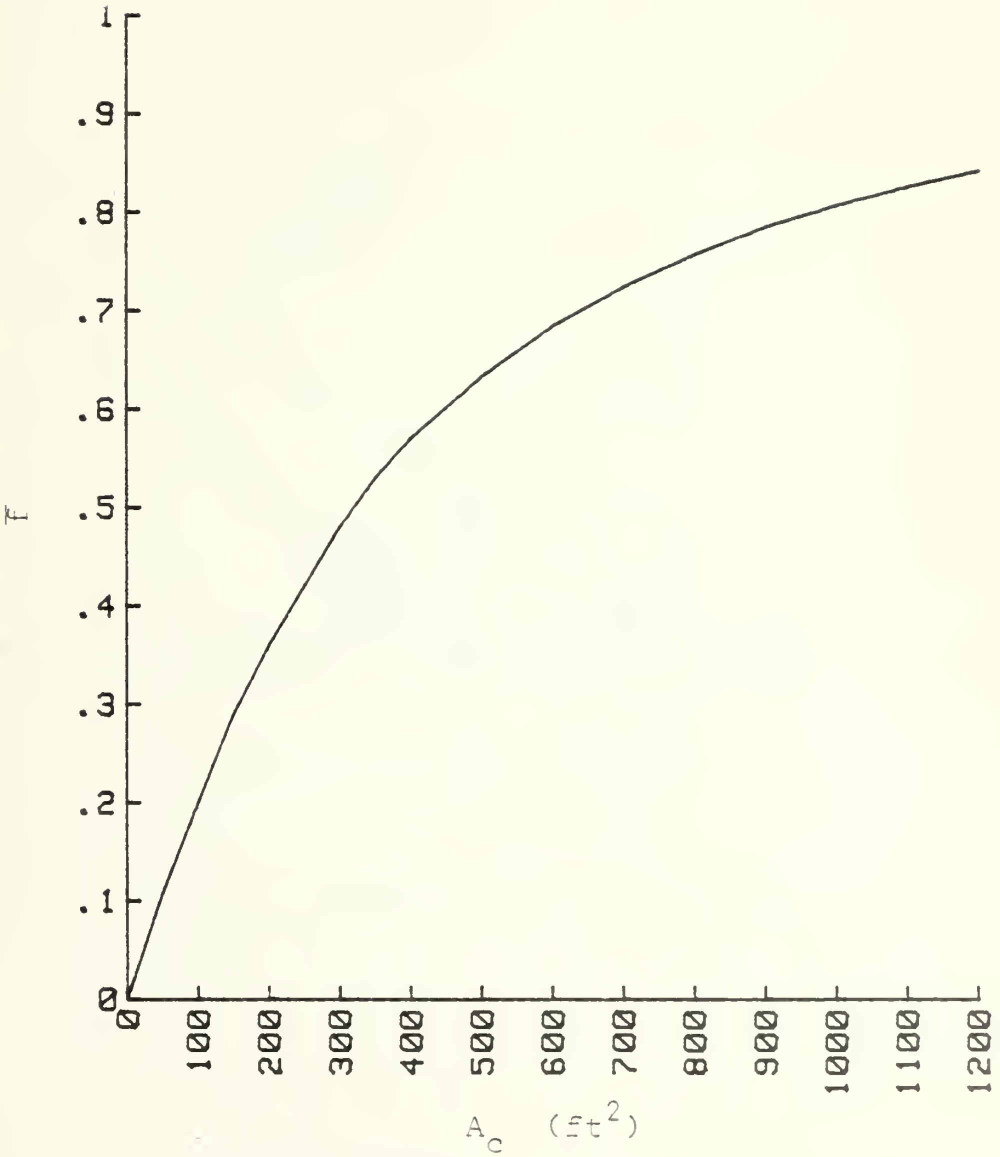

FIGURE 2 Typical $\bar{F}$ vs A_c

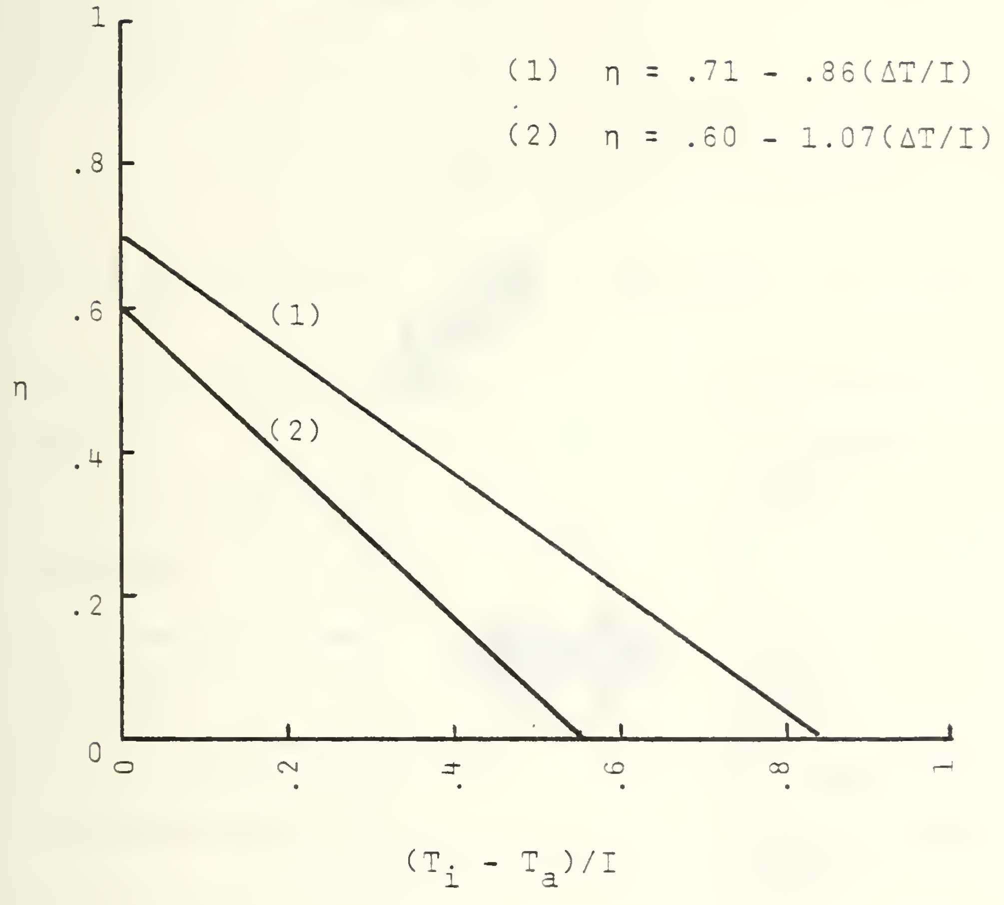

FIGURE 3 Typical Collector Efficiency Curves

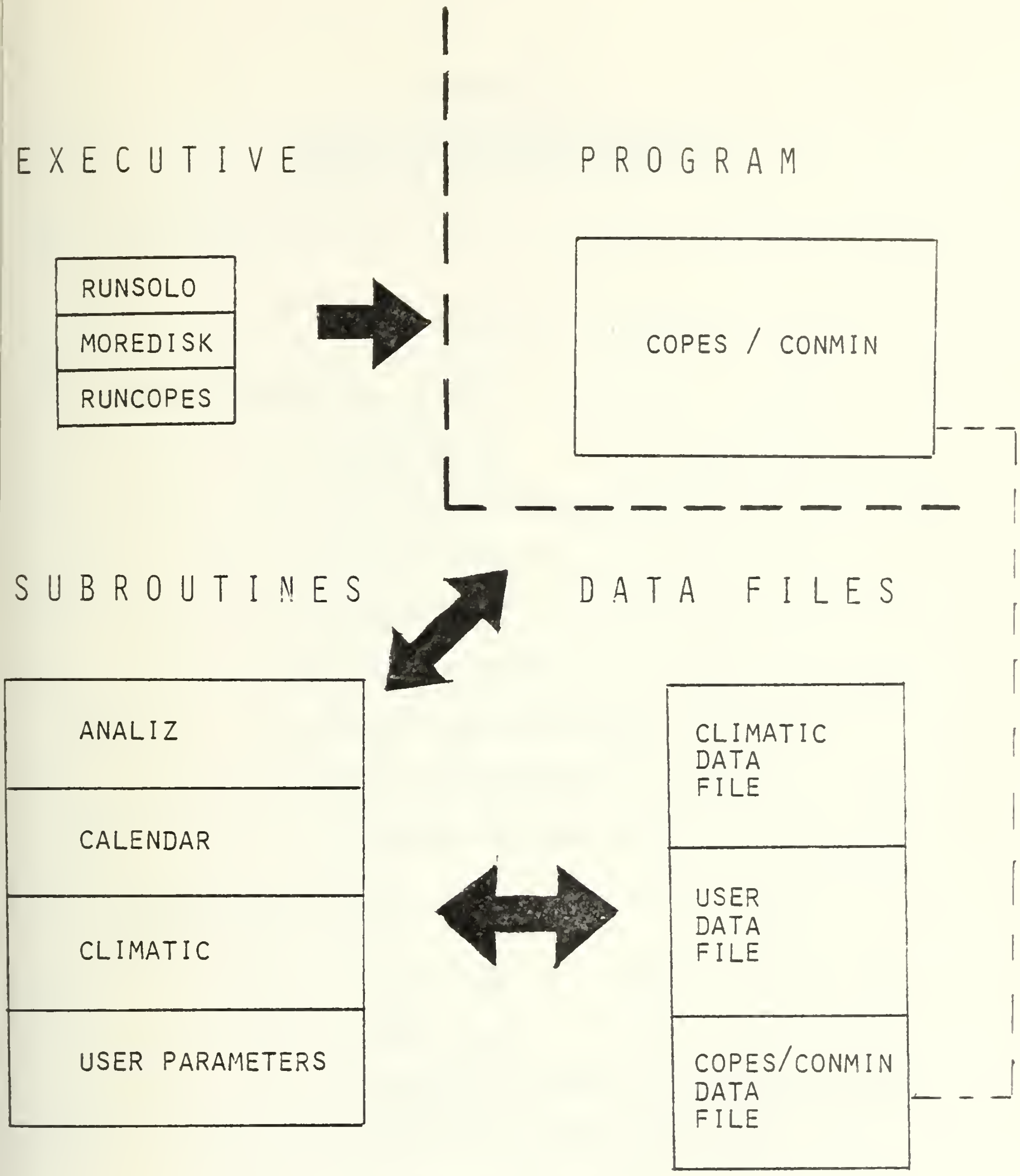

FIGURE 4 SOLOAD - COPES/CONMIN Interface

APPENDIX A

SUBROUTINE ANALIZ SUMMARY

A. OBJECTIVE FUNCTION

$$NPV = \bar{f}\, Q_L\, C_f\, F_i' - A_c\, C_s$$

B. DESIGN VARIABLES

Collector Area	A_c
Collector Tilt Angle	s
Collector Loop I.D.	d_i
Collector Loop O.D.	d_o
Heat Exchanger I.D.	d_{xi}
Collector Flow Velocity	v_c
Storage Flow Velocity	v_s
Heat Exchanger Length	L

C. DESIGN CONSTRAINTS

$G_1 = d_o - d_i$

$G_2 = d_{xi} - d_o$

G_3 = Reynolds number, Collector loop

G_4 = Reynolds number, Storage loop

G_5 = Capacity ratio, C_{min}/C_{max}

G_6 = 1st Flow parameter, $\zeta_1 = \dot{m}c_p/A_cF'U_L$

G_7 = 2nd Flow parameter, $\zeta_2 = \dot{m}c_p/A_cF_rU_l$

APPENDIX B

SOLOAD-1 Computer Program

```
C ************************************************************************
C *
C *  SSSSSSS  OOOOOOO  L         OOOOOOO     A      DDDDD             11   *
C * S         O     O  L         O     O    A A     D    D           111   *
C * S         O     O  L         O     O   A   A    D     D           11   *
C *  SSSSSSS  O     O  L         O     O  AAAAAAA   D     D  DDDD     11   *
C *         S O     O  L         O     O  A     A   D     D           11   *
C *         S O     O  L         O     O  A     A   D    D            11   *
C *  SSSSSSS  OOOOOOO  LLLLLLL   OOOOOOO  A     A   DDDDD         111111   *
C *                                                                        *
C ************************************************************************
C
C
C      SOLOAD-1 ( SOLAR OPTIMIZATION  ANALYSIS OR DESIGN ) IS A FORTRAN
C      SYSTEM FOR OPTIMIZATION OF SOLAR ENERGY CONVERSION SYSTEMS
C      WHICH UTILIZE FLAT PLATE COLLECTORS FOR GENERATING HEAT FOR
C      DOMESTIC SPACE AND WATER HEATING.  OPTIMIZATION IS BASED ON LONG
C      TERM PERFORMANCE MODELS AND INTEGRATION WITH A NET PRESENT
C      VALUE COST MODEL TO ACHIEVE  AN OBJECTIVE FUNCTION ( PROGRAM
C      SOLOAD-1: SUBROUTINE ANALIZ ) WHICH BECOMES THE PRIMARY INPUT
C      FOR THE COPES/CONMIN  OPTIMIZATION PROGRAM.  SEE 'SOLAR ENERGY
C      OPTIMIZATION, A METHODOLOGY', AN MSME THESIS WRITTEN AT THE
C      NAVAL POSTGRADUATE SCHOOL, MONTEREY, CALIFORNIA IN SEPTEMBER,
C      1979, BY LAWRENCE W. KOZOYED, LCDR, USN.
C
C
C
C      NOTE:  THIS IS AN AUXILIARY COMPACT LISTING OF THE SOLOAD-1
C             SYSTEM.  EACH FILE IS REQUIRED TO BE COMPILED SEPARATELY
C             BY INSERTING A USERID CARD AND A FILENAME READ CARD AT
C             THE HEAD OF EACH FILE.
C
C
C
C      SOLOAD-1 IS DESIGNED TO USE THE NAVAL POSTGRADUATE SCHOOL
C      CP/CMS TIME SHARING SYSTEM.  THE SOLOAD-1 DECK IS READ INTO THE
C      PRIVATE DISK.  THE PROCEDURE  TO USE THE SYSTEM IS SIMPLY:
C
C      1.  LOGIN WITH 512K CORE:  LOGIN ____P 512K
C
C      2.  EDIT FILE FT08F001 TO INCLUDE APPROPRIATE
C          USER INPUT DATA.
C
C      3.  EDIT FILE FT05F001 TO INCLUDE APPROPRIATE
C          COPES/CONMIN INPUT DATA.
C
C      4.  RUNSOLO TO LINK TO COPES/CONMIN
C
```

```
C      5.  MOREDISK TO OBTAIN SCRATCH FILES FOR COPES/CONMIN
C
C      6.  RUNCOPES TO EXECUTE SYSTEM
C
C
C      RUNSOLO IS AN EXECUTIVE PROGRAM WHICH LINKS THE USER(191) TO
C      THE COPES/CONMIN  DISK (I.E. LOCATED ON USERIC: 0981P) AND TO
C      ADDITIONAL TEMPORARY STORAGE DISKS.
C
C
C      MOREDISK IS AN EXEC PROGRAM WHICH OBTAINS  ADDITIONAL TEMPORARY
C      STORAGE DISKS.
C
C
C      RUNCOPES IS AN EXEC PROGRAM WHICH COMBINES THE FILES AND EXECUTES
C      THE SYSTEM.
C
C
C      BACKON IS AN EXEC PROGRAM FOR REENTRY INTO THE SYSTEM IF THE
C      CMS  IS LOST TO CP.
C
C
C      ANALYSE IS THE FILE NAME OF THE FORTRAN SUBROUTINE ANALIZ
C      AND IS USED IN TEXT VERSION
C
C
C
C
C      SETCAL IS A SUBROUTINE WHICH BUILDS A CALENDAR ARRAY.
C
C
C      FILE08 IS A SUBROUTINE TO READ IN THE USER DEFINED CONSTANTS
C      IN PROGRAM ANALIZ.  READIN IS FROM FILE FT08F001.
C
C
C      CMATIC IS A SUBROUTINE WHICH BUILDS THE CLIMATIC DATA
C      ARRAY CLIMAT(I,J,K) BY READING IN DATA FROM FILE FT09F001.
C
C
C      FILE FT05F001 IS AN INPUT DATA FILE FOR COPES/CONMIN WHICH
C      IS PREPARED BY THE USER.
C
C-----------------------------------------------------------------------
C
C      RUNSOLO EXEC P1
C
C      CP LINK 0981P 191 199 R PASS= COPES
C      LOGIN 199 A,P
```

```
C
C-----------------------------------------------------------------------
C
C     MCREDISK EXEC P1
C
C     VSET RDYMSG OFF
C     CP SET LINELN 130
C     &BEGSTACK
C     CP DEFINE T2314 192 8
C     FORMAT T ALL (NOTYPE)
C     RELEASE 192 T
C     LOGIN 192 P
C     LOGIN 191 B,P
C     &ENDSTACK
C
C-----------------------------------------------------------------------
C
C     RUNCOPES EXEC P1
C
C     &TYPEOUT OFF
C     GLOBAL T SYSLIB SSPLIB IMSLDP
C     FILEDEF 05 DSK FILE FT05F001
C     FILEDEF 07 DSK FILE FT07F001
C     FILEDEF 08 DSK FILE FT08F001
C     FILEDEF 09 DSK FILE FT09F001
C     FILEDEF 06 PRT
C     FILEDEF 02 DSK-P4 FILE FT02F001 RECFM VS LRECL 7290 BLKSIZE 7294
C     FILEDEF 04 DSK-P4 FILE FT04F001 RECFM VS LRECL 7290 BLKSIZE 7294
C     LOAD SOLOAD-1 COPES CONMIN (CLEAR NOMAP XEQ)
C
C-----------------------------------------------------------------------
C
C     BACKON EXEC P1
C
C     &BEGSTACK
C     RELEASE 192 T
C     LOGIN 192 P
C     LOGIN 191 B,P
C     LOGIN 199 A,P
C     &ENDSTACK
C
C
C
C-----------------------------------------------------------------------
C
C
C
C
C
```

```
C
C
C     DEFINITIONS
C
        XLIFE = LIFE NUMBER OF SYSTEM (YR)                                           SOL01420
       DISCON = PROJECTED DISCOUNT RATE OVER LIFE OF SYSTEM                          SOL01430
        FLATE = PROJECTED INFLATION RATE OVER LIFE OF SYSTEM                         SOL01440
                                                                                     SOL01450
                                                                                     SOL01460
       COSTIL = INITIAL COST                                                         SOL01470
       COSTCR = COLLECTOR COST QUOTED BY MFGR   ($/FT*FT)                            SOL01480
       COSTIN = SYSTEM INSTALLATION COST   ($/FT*FT)                                 SOL01490
       COSTTK = STORAGE TANK COST PER LB FLUID ($/LB)                                SOL01500
       OPTSTO = OPTIMUM STORAGE MASS PER COLLECTOR AREA (LB/FT*FT)                   SOL01510
       COSTHX = HEAT EXCHANGER COST PER HEX SURFACE ($/HEX FT*FT)                    SOL01520
       OPTHEX = OPTIMUM HEX SURFACE AREA PER COLLECTOR AREA                          SOL01530
                 (HEX FT*FT/CR FT*FT)                                                SOL01540
          XMR = PERCENTAGE OF INITIAL COST FOR MAINTENANCE,REPAIR                    SOL01550
                AND/OR REPLACEMENT                                                   SOL01560
       COSTPR = ANNUAL POWER COST TO OPERATE SYSTEM PER                              SOL01570
              COLLECTOR AREA                                                         SOL01580
       PUMPOW = PUMPING ENERGY REQUIRED (KWHR/FT*FT)                                 SOL01590
       NFUEL  = COMPARISON BASE INDICATOR: 1=OIL,2=ELE,3=GAS                         SOL01600
                                                                                     SOL01610
                                                                                     SOL01620
       ULOSSR = CONDUCTANCE OF BUILDING(BTU/HR FT*FT F)                              SOL01630
        AREAR = SURFACE HEAT TRANSFER AREA OF BUILDING (FT*FT)                       SOL01640
       HDD(I) = MONTHLY HEATING DEGREE DAYS ( HDD/MONTH )                            SOL01650
        DENTS = NUMBER OF RESIDENTS OF BUILDING (PER)                                SOL01660
       USEH2O = AVERAGE DAILY WATER  USEAGE PER RESIDENT (GAL/PER) *****SOL01670
       TEMH2O = DHW SUPPLY TANK DESIGN TEMPERATURE ( F )                             SOL01680
        TEMGR = MEAN TEMPERATURE OF GROUND SUPPLY WATER ( F )                        SOL01690
                                                                                     SOL01700
                                                                                     SOL01710
       I           = MONTHLY INDEX 1,12                                              SOL01720
       M           = DAILY INDEX 1,365                                               SOL01730
       K           = BEGINING DAY NUMBER FOR MONTH I                                 SOL01740
       L           = ENDING DAY NUMBER FOR MONTH I                                   SOL01750
       XXX(I,J)    = CALENDAR ARRAY: J=1 MONTHLY DAYS, J=2 MONTHLY                   SOL01760
                     BEGINNING DAY NUMBER, J=3 ENDING DAY NUMBER                     SOL01770
       DELTA(M)    = DECLINATION, RADIANS                                            SOL01780
       XOMEGA(M)   = DAILY HOUR ANGLE ON HORIZONTAL SURFACE                          SOL01790
       SOMEGA(M)   = DAILY HOUR ANGLE ON TILTED SURFACE                              SOL01800
       FOMEGA(M)   = MINIMUM DAILY HOUR ANGLE (H OR T)                               SOL01810
       DDRAT(M)    = DAILY RATIO OF DIRECT RADIATION COMPONENTS,                     SOL01820
                     TILTED TO HORIZONTAL                                            SOL01830
       DIO(M)      = DAILY IRRADIANCE ON HORIZONTAL SURFACE AT                       SOL01840
                     LATITUDE OF INTEREST, EXTRATERRESTRIAL                          SOL01850
```

```
      DIRRAT(I) = MONTHLY AVERAGE RATIO OF DIRECT COMPONENTS
      XIO(I)    = MONTHLY AVERAGE DAILY IRRADIANCE ON HORIZONTAL
                  SURFACE, EXTRATERRESTRIAL
      XKT(I)    = RATIO OF TOTAL HORIZONTAL RADIATION AT LOCATI-
                  ON OF INTEREST, LOCAL TO EXTRATERRESTRIAL
      DIFRAT(I) = RATIO OF DIFFUSE TO TOTAL RADIATION ON HORI-
                  ZONTAL SURFACE (LIU&JORDAN CORRELATION)
      RHO       = REFLECTIVITY OF GROUND AREA NEAR COLLECTOR
      SLOPE     = ANGLE AT WHICH COLLECTOR IS TILTED FROM THE
                  HORIZONTAL, FIXED FOR ALL MONTHS
      SLOCOR(I) = MONTHLY AVERAGE DAILY IRRADIANCE RATIO,
                  TILTED TO HORIZONTAL


      SUMFQ  = ANNUAL ENERGY LOAD PROVIDED BY SOLAR (BTU/YR)
      COSTFU = COST OF CONVENTIONAL ENERGY IN THE YEAR ANALYSIS
               IS CONDUCTED. ($/BTU)
      INTFAC = INTEREST FACTOR (INCLUDES INFLATION AND COST OF
               MONEY FACTORS)
      AREAC  = COLLECTOR AREA (SQFT)
      COSTSY = TOTAL SYSTEM COST COMPUTED PER COLLECTOR AREA
               ($/SQFT)

C*******************************************************************
C
C
C     SOLOAD-1  FORTRAN P1
C
C
      SUBROUTINE ANALIZ(ICALC)
C
      LOGICAL LANA,LDES
C
      COMMON/GLOBCM/AREAC,SLOPE,DIACTO,DIACTI,DIASTI,VELOC,VELOS,
     *HXLONG,XNPV,G1,G2,G3,G4,G5,G6,G7,COSTEN,OPTSLO,FBAR,SUMQ
C
      COMMON/FILE89/LOCATE
C
      COMMON/DAYS/XXX(12,3)
C
      COMMON/FILE8/NAME1,NAME2,NAME3,NAME4,
     *LANA,LDES,NFUEL,
     *NAME5,NAME6,NAME7,NAME8,NAME9,FRTA,FRUL,
     *TARAT,RHO,CSUBPC,CSUBPS,XLIFE,DISCON,FLATE,
     *COSTCR,COSTIN,COSTTK,OPTSTO,COSTHX,PUMPOW,
     *CSTOIL,CSTELE,CSTGAS,EFFOIL,EFFELE,EFFGAS,
     *ULOSSR,AREAR,DENTS,USEH2O,TEMH2O,TEMGR,
```

```
     *CCNDTU,DENSYC,DENSYS,RFOULC,RFOULS,
     *IDNUM,SEFFEC,TEMPCF,TEMPSF,CONDCF,CONDSF,
     *CCNOIL,CONELE,CONGAS,XMR
C
      COMMON/FILES/NAM10,NAM11,NAM12,NAM13,XLAT,
     *TAMB(12),HDD(12),WIND(12),XI(12),
     *XMEANT,HDDTCT,XMEANW,XMEANI
C
C
      DIMENSION QSUBI(12),QHLI(12),QDHWI(12),
     *DELTA(365),XOMEGA(365),SOMEGA(365),POMEGA(365),
     *DDRAT(365),CIO(365),DIRRAT(12),XIO(12),XKT(12),DIFRAT(12),
     *SLOCOR(12),SUMDIR(12),SUMIO(12),ARGN(365),AFGD(365),
     *COEFFI(12),Y(12),Z(12),FBARI(12)
C
C
      DATA PI/3.14159/
C
      RDEG=180./PI
      DRAD=PI/180.
C
      GO TO (1000,2000,3000),ICALC
1000  CONTINUE
C              ------------------------------
C
C                          INPUT SECTION
C
C              ------------------------------
C
C     OBTAIN DESIGN VARIABLE INITIAL VALUES
C
C     READ(5,1001)AREAC,SLOPE,DIACTO,DIACTI,DIASTI,
C    *VELOC,VELOS,HXLONG
C
C1001  FORMAT(8F9.4)
C
C     INITIALIZE CALENDAR ARRAY:
C     RETURN VIA COMMON/DAYS/
C
      CALL SETCAL
C
C     INITIALIZE USER DEFINED OPTIONS/INPUTS:
C     RETURN VIA COMMON/FILE8/
C
      CALL FILE08
C
      DLCTAN=24.0*ULOSSR*AREAR
C     INITIALIZE CLIMATIC DATA:
```

```
C      RETURN VIA COMMON/FILE9/
C
       CALL CMATIC
C
C
C
C
       WRITE(6,1500)LOCATE,IDNUM
 1500  FORMAT(1H1,////
      * ,T25,53H* * * * * * * * * * * * * * * * * * * * * * * * * * *,/
      * ,T25,53H*                                                   *,/
      * ,T25,53H*                   S O L O A D - 1                 *,/
      * ,T25,53H*                                                   *,/
      * ,T25,53H*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *,/
      * ,T25,53H*   ---          -             -         -          *,/
      * ,T25,53H*         DESIGN DATA OPTIONS/INPUTS SUMMARY        *,/
      * ,T25,53H*                                                   *,/
      * ,T25,53H* * * * * * * * * * * * * * * * * * * * * * * * * * *,/
      * ,T25,47H             >>>>>DATA MATCH TO OUTPUT ID NO.,I3,I3,/
      * ,T25,53H                                   IMCD-1 LWK AUGUST 1979)
C
       WRITE(6,1501)NAM10,NAM11,NAM12,NAM13,
      *            NAME5,NAME6,NAME7,NAME8,NAME9,
      *            NAME1,NAME2,
      *                  LOCATE,
      *                    XLAT,
      *                 XMEANT,   FRUL,
      *                 XMEANI,XLIFE,
      *                 HDDTOT,   FRTA,DISCON,
      *                  TEMGR,COSTCR,FLATE
 1501  FORMAT(1H0,////
      * ,T5,8HLOCATION,T19,4A4,T40,9HCOLLECTOR,T50,5A4,
      *                        T75,14HSTUDY APPROACH,T97,2A4,/
      * ,T5,8H--------,T40,9H---------,T75,14H--------------,//
      * ,T5,20HLOCATION INDEX......,7X,I3,T40,28HCOLLECTOR TEST RESULTS,
      *          ,T75,18HECONOMIC ESTIMATES,/
      * ,T5,20HLATITUDE,DEGREES....,4X,F6.2,T40,8H  SLOPE:
      *          ,T75,18H------------------,/
      * ,T5,20HMEAN TEMPERATURE....,F10.2
      *      ,T40,20H  PARAMETER,FRUL....,1X,F9.4,/
      * ,T5,20HINSOL(BTU/DAY FT**2),F10.2,T40,12H  INTERCEPT:,
      *        T75,20HSYSTEM LIFE(YEARS)..,1X,F9.2,/
      * ,T5,20HLOAD FACTOR,HDD.....,F10.2,T40,20H  PARAMETER,FRTA....
      *                                        ,1X,F9.4
      *        ,T75,20HDISCOUNT RATE ......,1X,F9.4,/
      * ,T5,20HMEAN GROUND TEMP....,F10.2,T40,20HBASE COST,$/FT**2...
      *   1X,F9.2,T75,20HINFLATION RATE......,1X,F9.4)
C
```

```
C
      WRITE(6,1502)NAME3, NAME4,TEMPCF,
     *                            DENSYC,
     *     EFFOIL,CSTOIL,CONOIL,CSUBPC,
     *     EFFELE,CSTELE,CONELE,CONDCF,
     *     EFFGAS,CSTGAS,CONGAS,TEMPSF
     *                           ,DENSYS
     *                           ,CSUBPS
     *                           ,CONDSF
C
C
1502  FORMAT(1H ,///
     *,T5,28HENERGY COMPARATIVE ESTIMATES,T57,19HSELECTED PARAMETERS,/
     *,T5,28H----------------------------,T57,19H-------------------,//
     * ,T5,40HTYPE ENERGY BASE.........................,T47,2A4
     *    ,T57,40HCOLLECTOR FLUID MEAN TEMPERATURE.........,F10.2,/
     * ,T5,50HINDEX TYPE EFFICIENCY    COST        HEATING VALUE   ,
     *     T57,40HCOLLECTOR FLUID DENSITY(LB/FT**3).......,F10.2,/
     * ,T7,1H1,T11,3HOIL,T16,F7.2,T25,F5.2,7H($/GAL),
     *          T38,F8.1,9H(BTU/GAL),
     *     T57,40HCOLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).,F10.4,/
     * ,T7,1H2,T11,3HELE,T16,F7.2,T25,F5.2,7H($/KWH),
     *          T38,F8.1,9H(BTU/KWH),
     *     T57,40HCOLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F),F10.4,/
     * ,T7,1H3,T11,3HGAS,T16,F7.2,T25,F5.2,7H($/THM),T38,F8.1,
     *9H(BTU/THM),T57,39HSTORAGE FLUID MEAN TEMPERATURE ........,F11.2,/
     *    ,T57,40HSTORAGE FLUID DENSITY(LB/FT**3).........,F10.2,/
     *    ,T57,40HSTORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...,F10.4,/
     * ,T5,40HHEAT LOAD CHARACTERISTICS               ,
     *     T57,40HSTORAGE FLUID CONDUCTIVITY(BTU/HR FT F).,F10.4)
C
C
      WRITE(6,1503)RFOULC,RFOULS,CONDTU,ULOSSR,OPTSTO,AREAR,RHO,
     *              DUCTAN,PUMPOW,TEMH2C,TARAT,USEH2O,COSTIN,DENTS,
     *              COSTHX,SEFFEC,COSTTK,XMR
C
C
1503  FORMAT( 1H ,
     *  T5,25H-------------------------,
     *     T57,40HCOLLECTOR SIDE FOULING FACTOR(HR F/BTU) ,F10.4,/
     *    ,T57,40HSTORAGE SIDE FOULING FACTOR(HR F/BTU)   ,F10.4,/
     *    ,T57,40HHEX TUBE CONDUCTIVITY(BTU/ HR FT F)......,F10.2,/
     * ,T5,40HLOAD LOSS COEFFICIENT (BTU/HR F FT**2)..,F10.2
     *    ,T57,40HESTIMATED OPTIMUM STORAGE(LB/AREAC) ....,F10.2,/
     * ,T5,40HLOAD SURFACE HEAT TRANSFER AREA(FT**2)..,F10.2
     *    ,T57,40HESTIMATED GROUND REFLECTANCE............,F10.2,/
     * ,T5,40HLOAD CONDUCTANCE (BTU/DEG F DAY).........,F10.2
     *    ,T57,40HESTIMATED PUMPING POWER(KWH/AREAC)......,F10.4,/
```

```
     * ,T5,40HDOMESTIC HOT WATER(DHW) DESIGN TEMP. ...,F10.2
     *     ,T57,40HESTIMATED CORRECTION FOR TAU ALPHA PREC.,F10.2,/
     * ,T5,40HESTIMATED DAILY DHW USEAGE (GAL/PER) ....,F10.2
     *     ,T57,40HESTIMATED INSTALL/LAECR COST ($/AREAC)..,F10.2,/
     * ,T5,40HESTIMATED DHW USERS (PER)...............,F10.2
     *     ,T57,40HESTIMATED HEX COST ($/FT**2) ...........,F10.2,/
     * ,T5,40HESTIMATED STORAGE TO LOAD EFFECTIVENESS.,F10.2
     *     ,T57,40HESTIMATED STORAGE TANK COST($/LB STORED),F10.2,/
     *     ,T57,40HMAINTENANCE (% INSTALLED COST/YR).......,F10.4)
C
C
C
C
      RETURN
2000  CONTINUE
C
C               ------------------------------
C
C                    ANALYSIS SECTION
C
C               ------------------------------
C
C       XNPV = NET PRESENT VALUE (THE OBJECTIVE FUNCTION)
C
C       XNPV = XNPV(FACINT,COSTFU,COSTSY,SUMFQ,AREAC)
C     FACINT = FACINT(XLIFE,DISCON,FLATE)
C     COSTFU = COSTFU(NFUEL,CST(N),CON(N),EFF(N))
C     COSTSY = COSTSY(COSTCR,COSTIN,COSTTK,COSTHX,CCSTPR,CPTSTC,
C              OPTHEX,XMR)
C      SUMFQ = SUMFQ(FACHEX,AREAC,QSUBI(I),FRTA,FRUL,XI(I),
C              SLOCOR(I),TAMB(I))
C     AREAC  = INDEPENDENT VARIABLE
C


      COMPUTE MAJOR DEPENDENT DESIGN VARIABLE
                     FACINT, INTEREST FACTOR  (DIMENSIONLESS)

C
C
      IF(DISCON.EQ.FLATE) GO TO 610
C
      ARG20 = (DISCON-FLATE)/(1.0 + FLATE)
C
      FACINT = (1.0-(1.0+ARG20)** (-XLIFE))/ARG20
      GO TO 620
610   FACINT = XLIFE
620   CONTINUE
```

```
C


      COMPUTE MAJOR DEPENDENT DESIGN VARIABLE
                    COSTFU, 1ST YEAR FUEL COST   ($/BTU)

C
C
C
      CONOIL=142000.
      CCNELE=3413.
      CONGAS=100000.
C
C
      IF(NFUEL.EQ.1)GO TO 523
      IF(NFUEL.EQ.2)GO TO 524
      CCSTFU=CSTGAS/(CONGAS*EFFGAS)
      GO TO 525
523   COSTFU=CSTOIL/(CONOIL*EFFOIL)
      GO TO 525
524   COSTFU=CSTELE/(CONELE*EFFELE)
525   CCNTINUE
C
C


      COMPUTE MAJOR DEPENDENT DESIGN VARIABLE
                    SUMFC, TOTAL ANNUAL SOLAR ENERGY PROVIDED (BTU/YR)


C
C
      DO 74 II=1,12
C
      QSUBI(II)=0.0
      SUMDIR(II)=C.0
      SUMIO(II)=0.0
      DIRRAT(II)=0.0
      XIO(II)=0.0
      XKT(II)=0.0
      DIFRAT(II)=0.0
      SLOCOR(II)=0.0
      CCEFF1(II)=0.0
      Y(II)=0.0
      Z(II)=0.0
      FBARI(II)=0.0
74    CONTINUE
C
```

```
C
C     COMPUTE COLLECTOR/STORAGE FLOWRATE AND CAPACITANCE
C
C
      ARECTO=PI*DIACTO*DIACTO/4.0
      ARECTI=PI*DIACTI*DIACTI/4.0
      AREAST=PI*(DIASTI*DIASTI-DIACTO*DIACTO)/4.0
      FLOWC=DENSYC*ARECTI*VELOC
      FLOWS=DENSYS*AREAST*VELOS
      CAPAC=3600.*FLOWC*CSUBPC
      CAPAS=3600.*FLOWS*CSUBPS
      GPMC=448.83*ARECTI*VELOC
      GPMS=448.83*AREAST*VELOS
      GPMCAR=GPMC/AREAC
      GPMSAR=GPMS/AREAC
C
C
C     OBTAIN MINIMUM CAPACITANCE FOR COLLECTOR/STORAGE HEAT EXCHANGER
C
C
      IF(CAPAC.LE.CAPAS) GO TO 19
      CMIN=CAPAS
      CMAX=CAPAC
      GO TO 21
19    CMIN=CAPAC
      CMAX=CAPAS
21    CONTINUE
C
C
C     COMPUTE COLLECTOR/STORAGE HEAT EXCHANGER COEFFICIENTS
C
C
      VIS104=0.708E-05
      PR104=4.34
      CND104=0.364
      VIS176=0.392E-05
      PR176=2.22
      CND176=0.387
C
      REYNC=(VELOC*DIACTI)/VIS176
      REYNS=(VELOS*(DIASTI-DIACTO))/VIS104
C
      RSTAR=DIACTO/DIASTI
C
      IF(REYNC.GE.2200.)GO TO 1025
      HXFRI=(CND176/DIACTI)*(48.0/11.0)
      GO TO 1026
1025  HXFRI=(CND176/DIACTI)*0.023*(REYNC**0.8)*(PR176**0.4)
```

```
1026  IF(REYNS.GE.5000.) GO TO 1027
      HXFRO=(CND104/(DIASTI-DIACTO))*4.534*(RSTAR**(-0.396))
      GC TO 1028
1027  ARG11=0.0234*RSTAR+0.8035
      HXFRO=(CND104/(DIASTI-DIACTO))*0.0289*(RSTAR**(-0.2645))
     1*REYNS**ARG11
1028  CONTINUE
C
C
C     COMPUTE COLLECTOR/STORAGE HEAT EXCHANGER EFFECTIVENESS, EFFECT
C
C
      RONE=1.0/HXFRI
      DRAT=DIACTO/DIACTI
      RTWO=DIACTI*ALOG(DRAT)/(2.0*CONCTU)
      RTHREE=1.0/(DRAT*HXFRO)
      RFOUR=RFOULC
      RFIVE=RFOULS
      UHEXI=1.0/(RONE+RTWO+RTHREE+RFOUR+RFIVE)
      AHEXI=PI*DIACTI*HXLONG
      AHEXO=PI*DIACTO*HXLONG
      OPTHEX=AHEXI/AREAC
      XNTU=UHEXI*AHEXI/CMIN
      CRAT=CMIN/CMAX
      ARG=-XNTU*(1.0-CRAT)
      EFFECT=(1.0-EXP(ARG))/(1.0-CRAT*EXP(ARG))
C
C     COMPUTE FLOWRATE CONSTRAINTS
C
      GCP=CAPAC/AREAC
      Z2=GCP/FRUL
      Z1=-1.0/ALOG(1.0-(1.0/Z2))
      FPP=Z1/Z2
C
C     COMPUTE COLLECTOR/STORAGE HEAT EXCHANGER FACTOR, FACHEX
C
C
      FACHEX=1.0/(1.0+(FRUL*AREAC/CAPAC)*(CAPAC/(EFFECT*CMIN)-1.0))
C
C
C
      DC 25 I=1,12
C
C
C     COMPUTE MCNTHLY ENERGY LOAD, QSUBI(I)
C
C
C
```

```
      QHLI(I)=24.*ULOSSR*AREAR*HDD(I)                                   SOL05700
      QDHWI(I)=8.34*XXX(I,1)*DENTS*USEH2O*(TEMH2O-TEMGR)                SOL05710
      QSUBI(I)=QHLI(I)+QDHWI(I)                                         SOL05720
C                                                                       SOL05730
C                                                                       SOL05740
C                                                                       SOL05750
C                                                                       SOL05760
C     COMPUTE MONTHLY COLLECTOR TILT SLOPE CORRECTION FACTOR,SLOCOR(I)  SOL05770
C                                                                       SOL05780
C                                                                       SOL05790
C                                                                       SOL05800
      K=XXX(I,2)                                                        SOL05810
      L=XXX(I,3)                                                        SOL05820
C                                                                       SOL05830
      DO 75 MM=1,365                                                    SOL05840
      DELTA(MM)=0.0                                                     SOL05850
      XOMEGA(MM)=0.0                                                    SOL05860
      SOMEGA(MM)=0.0                                                    SOL05870
      POMEGA(MM)=0.0                                                    SOL05880
      ARGN(MM)=0.0                                                      SOL05890
      ARGD(MM)=0.0                                                      SOL05900
      DDRAT(MM)=0.0                                                     SOL05910
      DIO(MM)=0.0                                                       SOL05920
75    CONTINUE                                                          SOL05930
C                                                                       SOL05940
C                                                                       SOL05950
      DO 8 M=K,L                                                        SOL05960
      XM=M                                                              SOL05970
      DELTA(M)=23.45*SIN(360.*((284.+XM)/365)*DRAD)                     SOL05980
      XOMEGA(M)=RDEG*ARCOS(-TAN(XLAT*DRAD)*TAN(DELTA(M)*DRAD))          SOL05990
      SOMEGA(M)=RDEG*ARCOS(-TAN((XLAT-SLOPE)*DRAD)*                     SOL06000
     *TAN(DELTA(M)*DRAD))                                               SOL06010
      IF(SOMEGA(M).GE.XOMEGA(M))GO TO 4                                 SOL06020
      POMEGA(M)=SOMEGA(M)                                               SOL06030
      GO TO 5                                                           SOL06040
4     POMEGA(M)=XOMEGA(M)                                               SOL06050
5     CONTINUE                                                          SOL06060
C                                                                       SOL06070
C                                                                       SOL06080
      ARGN(M)=(POMEGA(M)*DRAD)*SIN((XLAT-SLOPE)*DRAD)*SIN(DELTA(M)      SOL06090
     *        *DRAD)+COS((XLAT-SLOPE)*DRAD)                             SOL06100
     *        *COS(DELTA(M)*DRAD)*SIN(POMEGA(M)*DRAD)                   SOL06110
      ARGD(M)=(XOMEGA(M)*DRAD)*SIN(XLAT*DRAD)*SIN(DELTA(M)*DRAD)        SOL06120
     *        +COS(XLAT*DRAD)*COS(DELTA(M)*DRAD)*SIN(XOMEGA(M)*DRAD)    SOL06130
      DDRAT(M)=ARGN(M)/ARGD(M)                                          SOL06140
      DIO(M)=(24./PI)*429.*(DRAD*XOMEGA(M)*SIN(XLAT*DRAD)*SIN(DELTA(M)  SOL06150
     *       *DRAD)+COS(XLAT*DRAD)                                      SOL06160
     *       *COS(DELTA(M)*DRAD)*SIN(XOMEGA(M)*DRAD))                   SOL06170
```

```
      SUMDIR(I)=SUMDIR(I)+DDRAT(M)
      SUMIO(I)=SUMIO(I)+DIO(M)
8     CONTINUE
      DIRRAT(I)=SUMDIR(I)/XXX(I,1)
      XIO(I)=SUMIC(I)/XXX(I,1)
      XKT(I)=XI(I)/XIO(I)
      DIFRAT(I)=1.3903-4.0273*XKT(I)+5.5315*XKT(I)*XKT(I)
     *          -3.108*XKT(I)*XKT(I)*XKT(I)
C
      SLOCOR(I)=(1.0-DIFRAT(I))*DIRRAT(I)+DIFRAT(I)
     *          *(1.0+COS(SLOPE*DRAD))*.5+RHO*(1.0-COS(SLOPE*DRAD))*.5
C
C
C-----COMPUTE KLINE CORRELATION PARAMETERS
C
C
      COEFF1(I)=FACHEX*AREAC*XXX(I,1)/QSUBI(I)
      Y(I)=COEFF1(I)*FRTA*TARAT*XI(I)*SLOCOR(I)
      Z(I)=COEFF1(I)*FRUL*24.*(212.-TAME(I))
C
C
C
C-----COMPUTE MONTHLY LOAD FRACTIONS BASED ON KLINE CORRELATICN
C
C
      FBARI(I)=1.029*Y(I)-0.065*Z(I)-0.245*Y(I)*Y(I)+0.0018*Z(I)*Z(I)
     *+.0215*Y(I)*Y(I)*Y(I)
      IF(FBARI(I).GE.1.0)GO TO 255
      GC TO 256
255   FBARI(I)=1.0
256   CONTINUE
25    CONTINUE
C
C
C-----COMPUTE  ANNUAL SOLAR ENERGY  PROVIDED ,  SUMFQ
C
C
C
      SUMHL=0.0
      SUMDHW=0.0
      SUMQ=0.0
      SUMFQ=0.0
      DO 825 I=1,12
      SUMHL=SUMHL+QHLI(I)
      SUMDHW=SUMDHW+QDHWI(I)
      SUMQ=SUMQ+QSUBI(I)
      SUMFQ=SUMFQ+FBARI(I)*CSUBI(I)
825   CONTINUE
```

```
      FBAR=SUMFQ/SUMQ                                                   SOL06660
C                                                                       SOL06670
C                                                                       SOL06680
                                                                        SOL06690
                                                                        SOL06700
      COMPUTE MAJOR DEPENDENT DESIGN VARIABLE                           SOL06710
                    COSTSY, SYSTEM COST ($/FT**2 COLLECTOR AREA)        SOL06720
                                                                        SOL06730
                                                                        SOL06740
C                                                                       SOL06750
C                                                                       SOL06760
      CCSTIL=COSTCR+COSTIN+COSTTK*OPTSTO+COSTHX*OFTHEX                  SOL06770
C                                                                       SOL06780
      CCSTPR=PUMPCW*CSTELE                                              SOL06790
C                                                                       SOL06800
      CCSTSY=COSTIL+FACINT*(COSTIL*XMR+COSTPR)                          SOL06810
C                                                                       SOL06820
C                                                                       SOL06830
      CCSTTO=COSTIL*AREAC                                               SOL06840
C                                                                       SOL06850
C                                                                       SOL06860
C     CCNSTRAINT EQJATICNS                                              SOL06870
C                                                                       SOL06880
C                                                                       SOL06890
      G1=DIASTI-DIACTO                                                  SOL06900
      G2=DIACTO-DIACTI                                                  SOL06910
      G3=REYNC                                                          SOL06920
      G4=REYNS                                                          SOL06930
      G5=CRAT                                                           SOL06940
      G6=Z2                                                             SOL06950
      G7=Z1                                                             SOL06960
C                                                                       SOL06970
C                                                                       SOL06980
C                                                                       SOL06990
C                                                                       SOL07000
C                                                                       SOL07010
      XNPV=FACINT*COSTFU*SUMFQ-COSTSY*AREAC                             SOL07020
C                                                                       SOL07030
      COSTEN=(COSTFU*FACINT/XLIFE)-(XNPV/(XLIFE*SUMQ))                  SOL07040
      CFTSLO=CCSTSY/(FACINT*COSTFU*SUMQ)                                SOL07050
C                                                                       SOL07060
C                                                                       SOL07070
      RETURN                                                            SOL07080
 3000 CONTINUE                                                          SOL07090
C                                                                       SOL07100
C                                                                       SOL07110
C                -----------------------------                          SOL07120
C                                                                       SOL07130
```

```
C                             CUTPUT SECTION
C
C               ------------------------------
C
C
C
      WRITE(6,3500)NAME1,NAME2,NAM10,NAM11,NAM12,NAM13,LCCATE,ICNUM
3500  FORMAT(1H1,////
     * ,T25,53H* * * * * * * * * * * * * * * * * * * * * * * * * * *,/
     * ,T25,53H*                                                   *,/
     * ,T25,53H*                  S O L O A D - 1                  *,/
     * ,T25,53H*                                                   *,/
     * ,T25,53H*   SOLAR ENERGY OPTIMIZATION ANALYSIS CR DESIGN    *,/
     * ,T25,53H*   ---              -              -         -     *,/
     * ,T25,18H*     RESULTS OF ,2A4,5H FOR ,4A4,6H      *,/
     * ,T25,53H*                                                   *,/
     * ,T25,53H* * * * * * * * * * * * * * * * * * * * * * * * * * *,/
     * ,T25,47H             >>>>>DATA MATCH TO INPUT ID NO.,I3,I3,/
     * ,T25,53H                          OMOD-1 LWK AUGUST 1975)
C
C
      WRITE(6,3501)
C
3501  FORMAT(1H ,////
     *    ,T27,7HHEATING,T73,6HEXTRA-,T87,9HCOLLECTOR,T98,5HSOLAR,/
     *    ,T12,10HHORIZONTAL,T27,6HDEGREE,T36,7HAMBIENT,T49
     *,7HHEATING,T62,3HDHW,T73,11HTERRESTRIAL,T87,4HTILT,T98
     *                                                  ,6HENERGY,/
     *,T5,5HMONTH,T12,10HINSOLATION,T27,4HDAYS,T36,11HTEMPERATURE,T49
     *,4HLOAD,T62,4HLOAD,T73,10HINSOLATION,T87,6HFACTOR,T98,8HFRACTION,/
     * //,T12,13HBTU/DAY FT**2,T27,7HDEG DAY,T39,5HDEG F
     *    ,T49,37HBTU/MONTH    BTU/MONTH  BTU/DAY FT**2,/
     * ,T5,5H-----,T12,13H-------------,T27,7H-------,T36
     *    ,11H-----------,T49,9H---------,T62,9H---------
     *    ,T73,13H-------------,T87,9H---------,T98,8H--------)
C
C
C
      WRITE(6,3502) (XI(IR),HDD(IR),TAME(IR),QHLI(IR),QCHWI(IR)
     *              ,XIO(IR),SLOCOR(IR),FBARI(IR), IR=1,6)
C
3502  FORMAT( 1H ,/
     *,T5,4H JAN,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *           ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H FEB,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *           ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H MAR,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
```

```
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H APR,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     * T5,4H MAY,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H JUN,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3)
C
C
      WRITE(6,3503) (XI(IR),HDD(IR),TAMB(IR),QHLI(IR),QDHWI(IR)
     *              ,XIO(IR),SLOCOR(IR),FBARI(IR), IR=7,12)
     *                                 ,HDDTOT,SUMHL,SUMDHW,FBAR
C
C
3503  FORMAT(1H ,
     * T5,4H JUL,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H AUG,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H SEP,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H OCT,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H NOV,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,4H DEC,T15,F6.1,T27,F6.1,T39,F6.1,T48,E11.4,T61,E11.4
     *               ,T77,F6.1,T89,F5.3,T100,F5.3,/
     *,T5,5HTOTAL,T25,F8.1,T48,E11.4,T61,E11.4,/
     *                ,T77,19H>>WEIGHTED AVERAGE,T100,F5.3)
C
      WRITE(6,3504)AREAC,CAPAC
     *             ,SLOPE,CAPAS
     *             ,DIACTI,HXFRI
     *             ,DIACTO,HXFRO
     *             ,DIASTI,GPMC
     *             ,VELOC,GPMS
3504  FORMAT(1H ,T18
     *     ,28HDESIGN VARIABLES/CONSTRAINTS,T72,16HOTHER PARAMETERS,/
     *  ,T18,28H----------------------------,T72,16H----------------,/
     *        ,T5,40HCOLLECTOR AREA   (FT**2) ............>>>,F10.2
     *       ,T57,40HCOLLECTOR SIDE CAPACITY (BTU/HR  F).....,E10.3,/
     *        ,T5,40HCOLLECTOR TILT ANGLE  (DEG) .........>>>,F10.2
     *       ,T57,40HSTORAGE SIDE CAPACITY (BTU/HR  F).......,E10.3,/
     *        ,T5,40HCOLLECTOR SIDE TUBE INNER DIA. (FT) ....,F10.4
     *       ,T57,40HCOLLECTOR SIDE CONVECTION COEFF.........,F10.4,/
     *        ,T5,40HCOLLECTOR SIDE TUBE OUTER DIA. (FT) ....,F10.4
     *       ,T57,40HSTORAGE SIDE CONVECTION COEFFICIENT ....,F10.4,/
     *        ,T5,40HSTORAGE SIDE TUBE(HEX) INNER DIA. (FT)..,F10.4
```

```
     *     ,T57,40HCOLLECTOR SIDE FLOW RATE  (GPM) .........,F10.4,/
     *      ,T5,40HCOLLECTOR SIDE FLUID VELOCITY (FT/SEC)..,F10.4
     *     ,T57,40HSTORAGE SIDE FLOW RATE  (GPM) ...........,F10.4)
C
C
      WRITE(6,3505)VELOS,GPMCAR
     *             ,HXLONG,GPMSAR
     *                    ,EFFECT
     *                ,G1,SUMFQ
     *                ,G2,SUMQ
     *                ,G3,FBAR
     *                ,G4,XNPV
     *                ,G5,UHEXI
C
C
3505  FORMAT(1H ,
     *        T5,40HSTORAGE SIDE FLUID VELOCITY  (FT/SEC) ..,F10.4
     *     ,T57,40HNORMALIZED COLLECTOR FLOW (GPM/AREAC)...,F10.4,/
     *      ,T5,40HHEAT EXCHANGER LENGTH (FT) ..............,F10.2
     *     ,T57,40HNORMALIZED STORAGE FLOW  (GPM/AREAC) ...,F10.4,/
     *      ,T5,40H//////////////CONSTRAINTS//////////////
     *     ,T57,40HHEAT EXCHANGER EFFECTIVENESS............,F10.4/
     *      ,T5,40HHEX ANNULAR DIAMETER DIFFERENCE (FT)....,F10.4
     *     ,T57,40HSOLAR ENERGY DELIVERED (BTU/YEAR).......,E10.3,/
     *      ,T5,40HCOLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).,F10.4
     *     ,T57,40HTOTAL ENERGY DEMAND  (BTU/YEAR) ........,E10.3,/
     *      ,T5,40HCOLLECTOR SIDE REYNOLDS NUMBER..........,E10.3
     *     ,T57,40HANNUAL AVERAGE SOLAR LOAD FRACTION .....,F10.4,/
     *      ,T5,40HSTORAGE SIDE REYNOLDS NUMBER ...........,E10.3
     *     ,T57,40HOBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>,E10.3,/
     *      ,T5,40HCAPACITY RATIO (CMIN/CMAX)..............,F10.4
     *     ,T57,40HHEX COEFFICIENT (BTU/HR F FT**2)........,F10.2)
C
C
      WRITE(6,3506)G6,COSTTC,G7,FPP
C
C
3506  FORMAT(1H ,
     *        T5,40HFLOW PARAMETER Z2(GCF/FRUL)...............,F10.4
     *     ,T57,40HTOTAL INSTALLATION COST ($) .............,F10.2,/
     *      ,T5,40HFLOW PARAMETER Z1(GCF/FRPUL)............,F10.2
     *     ,T57,40HCOLLECTOR FLOW FACTOR(FPP)...............,F10.4)
C
C
      WRITE(6,3507)
3507  FORMAT(1H1,///////,28HERROR MESSAGES IF ANY FOLLOW)
      RETURN
      END
```

```
C                 --------------------------------
C
C                     SUBROUTINE SECTION
C
C                 --------------------------------
C
C
C|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
C
C
C
C
C|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||
C
C
      SUBROUTINE SETCAL
C
C-----THIS FILE IS SET UP TO  ESTABLISH THE CALENDAR ARRAY
C     XXX(I,J).   I IS THE MONTH NUMBER, J=1 IS  DAYS PER MONTH
C     J=2 IS THE JULIAN DAY NUMBER FOR THE FIRST DAY OF THE
C     MONTH AND J=3 IS THE JULIAN DAY NUMBER FOR THE LAST DAY
C     OF THE MONTH.
C
      COMMON/DAYS/XXX(12,3)
C
      XXX(1,1)=31.
      XXX(2,1)=28.
      XXX(3,1)=31.
      XXX(4,1)=30.
      XXX(5,1)=31.
      XXX(6,1)=30.
      XXX(7,1)=31.
      XXX(8,1)=31.
      XXX(9,1)=30.
      XXX(10,1)=31.
      XXX(11,1)=30.
      XXX(12,1)=31.
C
      XXX(1,2)=1.
      XXX(1,3)=31.
C
C
      DO 251 I=2,12
      K=I-1
C
      XXX(I,2)=XXX(K,3) + 1.
      XXX(I,3)=XXX(K,3) + XXX(I,1)
C
```

```
251   CONTINUE                                                    SOL09060
C                                                                 SOL09070
      RETURN                                                      SOL09080
      END                                                         SOL09090
C                                                                 SOL09100
C                                                                 SOL09110
C|||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||SOL09120
      SUBROUTINE FILE08                                           SOL09130
C                                                                 SOL09140
C                                                                 SOL09150
C     THIS FILE IS SET UP TC ALLOW USER INPUT FOR CERTAIN         SOL09160
C     PARAMETERS WHICH WILL REMAIN CONSTANT .                     SOL09170
C                                                                 SOL09180
      COMMON/FILE89/LOCATE                                        SOL09190
C                                                                 SOL09200
C                                                                 SOL09210
      COMMON/FILE8/NAME1,NAME2,NAME3,NAME4,                       SOL09220
     *LANA,LDES,NFUEL,                                            SOL09230
     *NAME5,NAME6,NAME7,NAME8,NAME9,FRTA,FRUL,                    SOL09240
     *TARAT,RHO,CSUBPC,CSUBPS,XLIFE,DISCON,FLATE,                 SOL09250
     *CCSTCR,COSTIN,COSTTK,OPTSTO,COSTHX,PUMPOW,                  SOL09260
     *CSTOIL,CSTELE,CSTGAS,EFFOIL,EFFELE,EFFGAS,                  SOL09270
     *ULOSSR,AREAR,DENTS,USEH2O,TEMH2O,TEMGR,                     SOL09280
     *CCNDTU,DENSYC,DENSYS,RFOULC,RFOULS,                         SOL09290
     *IDNUM,SEFFEC,TEMPCF,TEMPSF,CONDCF,CONDSF,                   SOL09300
     *CCNOIL,CONELE,CONGAS,XMR                                    SOL09310
C                                                                 SOL09320
C                                                                 SOL09330
      READ(8,800) NAME1,NAME2,NAME3,NAME4                         SOL09340
      READ(8,801) LANA,LDES,LOCATE,NFUEL                          SOL09350
      READ(8,802) NAME5,NAME6,NAME7,NAME8,NAME9,FRTA,FRUL         SOL09360
      READ(8,803) TARAT,RHO,CSUBPC,CSUBPS,XLIFE,DISCON,FLATE      SOL09370
      READ(8,804) COSTCR,COSTIN,COSTTK,CPTSTO,CCSTHX,PUMPCW       SOL09380
      READ(8,804) CSTOIL,CSTELE,CSTGAS,EFFOIL,EFFELE,EFFGAS       SOL09390
      READ(8,804) ULOSSR,AREAR,DENTS,USEH2O,TEMH2C,TEMGR          SOL09400
      READ(8,805) CONDTU,DENSYC,DENSYS,RFOULC,RFOULS              SOL09410
      READ(8,806) IDNUM,SEFFEC,TEMPCF,TEMPSF,CONDCF,CONDSF        SOL09420
      READ(8,807) CONOIL,CCNELE,CCNGAS,XMR                        SOL09430
C                                                                 SOL09440
C                                                                 SOL09450
800   FCRMAT(////////////,4A4)                                    SOL09460
801   FORMAT(//////,2L1,2I3)                                      SOL09470
802   FORMAT(////,5A4,2F9.4)                                      SOL09480
803   FORMAT(//,7F9.4)                                            SOL09490
804   FORMAT(//,6F9.4)                                            SOL09500
805   FCRMAT(//,5F9.4)                                            SOL09510
806   FORMAT(//,I5,5F9.4)                                         SOL09520
807   FCRMAT(//,3F8.1,1F9.4)                                      SOL09530
```

```
      RETURN
      END
C
C
C
C
      SUBROUTINE CMATIC
C
C
C     THIS FILE IS SET UP TO PROVIDE CLIMATILOGICAL DATA FOR
C     THE 97 LOCATIONS DEFINED BY NOAA. INFORMATION INCLUDES
C     LATITUDE, (XLAT) , ETC
C
      COMMON/FILE89/LOCATE
C
C
      COMMON/FILE9/NAM10,NAM11,NAM12,NAM13,XLAT,
     *TAMB(12),HDD(12),WIND(12),XI(12),
     *XMEANT,HDDTOT,XMEANW,XMEANI
C
      DIMENSION LOCNM(20),NAME10(20),NAME11(20),NAME12(20),NAME13(20),
     *XXLAT(20),CLIMAT(20,12,4)
C
      DO 900 LL=1,20
      READ(9,902)LOCNM(LL),NAME10(LL),NAME11(LL),NAME12(LL),NAME13(LL),
     *XXLAT(LL)
      READ(9,903) ((CLIMAT(LL,I,K),I=1,12),K=1,4)
900   CONTINUE
C
      L=LOCATE
      XLAT=XXLAT(L)
      NAM10=NAME10(L)
      NAM11=NAME11(L)
      NAM12=NAME12(L)
      NAM13=NAME13(L)
C
      SUMT=0.0
      SUMH=0.0
      SUMW=0.0
      SUMI=0.0
      DO 901 I=1,12
      TAMB(I)=CLIMAT(L,I,1)
      HDD(I)=CLIMAT(L,I,2)
      WIND(I)=CLIMAT(L,I,3)
      XI(I)=CLIMAT(L,I,4)
      SUMT=SUMT+TAMB(I)
      SUMH=SUMH+HDD(I)
```

```
      SLMW=SUMW+WIND(I)                                                    SOL10030
      SUMI=SUMI+XI(I)                                                      SOL10040
901   CCNTINUE                                                             SOL1C050
C                                                                          SOL10060
      XMEANT=SUMT/12.0                                                     SOL10070
      HDDTOT=SUMH                                                          SOL1C08C
      XMEANW=SUMW/12.0                                                     SOL10090
      XMEANI=SUMI/12.0                                                     SOL10100
C                                                                          SOL10110
902   FORMAT(I4,4A4,F6.2)                                                  SOL10120
903   FCRMAT(12F6.1)                                                       SOL1013C
                                                                           SOL10140
      RETURN                                                               SOL10150
      END                                                                  SOL10160
C                                                                          SCL10170
C                                                                          SOL10180
C||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||SOL10190
C                                                                          SOL10200
C                                                                          SOL1C210
C                                                                          SOL10220
C||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||||SOL10230
```

APPENDIX C

SOLOAD-1 Data Files

```
$     COPES/CONMIN INPUT DATA:  FILE FTC5F001
$
$    SOLAR ENERGY OPTIMIZATICN ANALYSIS CF DESIGN
$
$
$     NCALC          NDV          NSV       N2VAR      IPNFUT      IPSENS     IPZVAR
          2            8            0           C           2           0          0
$
$    IPRINT        ITMAX       ICNDIR       NSCAL        ITRM      LINCBJ     NACMX1       NFDG
          1          500            0           5           0           0          0          0
$
$      FDCH        FDCHM           CT       CTMIN         CTL      CTLMIN      THETA
       0.01        0.001        -0.05       0.004       -0.01       C.CC1        1.0
$
$    DELFUN       DABFUN       ALPHAX      ABOBJ1
      0.001        0.001          0.1         0.1
$
$    NDVTOT         IOBJ       SGNOBJ
          0            9         +1.0
$
$     DESIGN VARIABLE LIMITS: BOUNDS/INITIAL VALUE/SCALE FACTOR
$
$    V.LB       V.UB        X.       SCAL.
$
$          COLLECTOR AREA      (FT**2)
  100.0     2000.0      400.0
$
$          COLLECTOR TILT ANGLE     (DEGREES)
    C.0       90.0       60.0
$
$          PRIMARY LOOP OUTER DIAMETER     (FEET)
   .005        .30       0.05
$
$          PRIMARY LOOP INNER DIAMETER     (FEET)
   .004        .28       0.03
$
$          STORAGE LOOP HEX CASING INNER CIAMETER     (FEET)
    .05        1.0       0.10
$
$          PRIMARY LOOP FLUID VELOCITY     (FT/SEC)
    1.0     3000.0       20.0
$
$          STORAGE LOOP FLUID VELOCITY     (FT/SEC)
    1.0      100.0       10.0
$
$          HEX LENGTH      (FEET)
    5.0      500.0        6.0
$
```

```
$     DESIGN VARIABLE IDENTIFICATION
$
$     NDSGN       IDSGN      A.MULT
          1           1         1.0
          2           2         1.0
          3           3         1.0
          4           4         1.0
          5           5         1.0
          6           6         1.0
          7           7         1.0
          8           8         1.0
$
$     NCONS
          7
$
$     CONSTRAINT FUNCTION IDENTIFICATION AND BOUNDS
$
$         HEX ANNULAR THICKNESS     (FEET)
         10          10          1
      0.005                   10.0
$
$         PRIMARY LOOP DOUBLE THICKNESS     (FEET)
         11          11          1
      0.005                   0.01
$
$         PRIMARY LOOP REYNOLDS NUMBER     (DIMENSICNLESS)
         12          12          0
        C.0                .49E 06
$
$         STORAGE LCOP REYNOLDS NUMBER    ·(DIMENSIONLESS)
         13          13          0
        0.0                .50E 06
$
$         CAPACITY RATIO     CMIN/CMAX     (DIMENSIONLESS)
         14          14          0
     0.0001                  0.999
$
$         FLOW PARAMETER Z2 (GCP/FRUL)  (DIMENSIONLESS)
         15          15          0
        1.0                .10E 08
$
$         FLOW PARAMETER Z1 (GCP/FRPUL)  (DIMENSIONLESS)
         16          16          0
        9.0                   16.0
$
$         INITIAL VALUES TO BE READ IN FCLLOW .....END
END
  60C.0      50.0      0.05      0.03      0.10     20.0      20.0      6.0
```

```
$
$      SCLOAD-1 SYSTEM USER DEFINED OPTICNS:   FILE FT08F001
$
$
$      THIS FILE IS CALLED BY THE SOLOAC-1 SYSTEM SUBROUTINE
$      FILE08 AND ALLOWS COMPLETE FLEXIBILITY FOR THE USER IN
$      CHOOSING VARIOUS PARAMETERS.
$
$ STUDY APPROACH:NAME1,NAME2(2A4) ; ENERGY COMPARISON:NAME3,NAME4(2A4)
$                ANALYSIS/DESIGN                        OIL/ELECTRIC/GAS
$
ANALYSIS     OIL
$
$ LOGICAL INDEX(ANALYSIS):LANA(1L1);  LOGICAL INDEX(DESIGN):LDES(1L1);
$                         T/F                                T/F
$ LOCATION INDEX: LOCATE(I3); ENERGY INDEX: NFUEL(I3)
$                 1/2/3.../97                1=OIL/2=ELE/3=GAS
$
TF 10  1
$
$ COLLECTOR MANUFACTURER: NAME5/6/7/8/9 (5A4);
$ INTERCEPT PARAMETER: FRTA(F9.4); SLOPE PARAMETER: FRUL(F9.4)
$
FEDERAL PRISON I. D     .627     .883
$
$   TARAT      RHO    CSUBPC    CSUBPS     XLIFE    DISCON     FLATE
    .93       .20     1.0       1.0       20.        .0900     .1100
$
$  COSTCR    COSTIN    COSTTK    OPTSTO    COSTHX    PUMPOW
   9.4     10.       00.08     15.30      5.00     1.00
$
$  CSTOIL    CSTELE    CSTGAS    EFFOIL    EFFELE    EFFGAS
    .90       .05       .40       .70       .99       .70
$
$  ULOSSR     AREAR     DENTS    USEH2O    TEMH2O     TEMGR
    .09  5000.        6.        20.      140.       55.
$
$  CONDTU    DENSYC    DENSYS    RFOULC    RFOULS
 220.0      60.81     62.09     0.001     0.001
$
$   IDNUM    SEFFEC    TEMPCF    TEMPSF    CONDCF    CONDST
      233    1.0      176.0     104.0      0.387     0.364
$
$ CONOIL  CONELE  CONGAS      XMR
142000.   3413. 100000.    .001
$
$
$
```

```
$
$     SOLOAD-1 SYSTEM CLIMATIC DATA:  FILE FT09F001
$     THIS FILE IS CALLED BY SUBROUTINE CMATIC
$
$
$     LINE 1 INCLUDES LOCATION NUMBER,CITY,STATE, AND LATITUDE
$     LINE 2 CONTAINS MONTHLY MEAN AMBIENT TEMPERATURES
$     LINE 3 CONTAINS MONTHLY HEATING DEGREE DAYS
$     LINE 4 CONTAINS MONTHLY MEAN WIND SPEEDS , MI/HR  (N.A. SOLOAD-1)
$     LINE 5 CONTAINS MONTHLY AVERAGE DAINLY INSOLATION , BTU/FT**2 DAY
$
$
$
1   LACROSSE     WISC 43.87
  15.4  20.7  31.0  47.0  58.7  68.5  72.5  70.4  60.8  50.9  35.4  22.1
1536.11253.11055.6 546.8 235.2 42.3   6.9  19.1 174.1 444.3 886.91331.2     8.7
   8.7   5.7   9.2  10.6   9.8   8.3   7.6   7.4   8.1   9.3   9.7   8.6
 481.3 764.51100.81426.21712.81905.51900.51666.31241.9 863.5 493.9 369.5
2   SHERIDAN  WYOMING 44.77
  21.0  26.7  32.4  43.0  53.6  62.6  70.8  69.5  57.8  46.9  32.6  25.3
1364. 1083. 1012.  661.4 359.7 127.6  17.3  34.3 241.8 562.  973. 1230.8
   7.8   8.1   9.1   9.8   8.9   7.9   7.1   7.2   7.4   7.5   7.8   7.8
 517.5 788.31204.81537.21882.72156. 2329. 2006. 1502. 1006.  591.  441.4
3   SALEM        OREGON 44.92
  39.7  42.3  44.4  48.6  54.9  60.6  66.2  65.4  61.0  52.2  44.8  40.9
 783.5 642.5 638.9 493.6 316.2 154.7  46.2  50.1 140.6 397.1 605.6 748.
   6.8   7.8   8.2   7.4   6.7   6.6   6.5   6.3   6.2   6.2   7.4   8.2
 332.1 588.0 947.11370.41737.81841.62142.41774.71328.3 769.4 410.4 277.4
4   PORTLAND     MAINE 43.65
  22.2  24.2  32.3  42.8  52.9  62.7  68.0  66.6  59.0  48.8  38.8  26.3
1327.81152.71013.4 664.7 379.9 118.5  22.1  42.0 202.8 502.1 785.41199.0
   9.5   9.8  10.4  10.2   9.5   8.4   7.8   7.7   8.0   8.6   8.8   9.3
 450.3 681.6 969.61304. 1567. 1712. 1659. 1461. 1158.  822.3 459.2 362.8
5   INDIANAPOLIS   IN 39.73
  27.2  31.0  39.8  52.5  62.4  71.9  74.9  72.9  66.2  54.7  41.7  31.4
1172.5 961.7 781.4 385.3 144.2  15.7   1.2   4.3  74.0 332.9 700.61042.3
  10.9  11.2  11.8  11.4   9.7   8.6   7.4   7.2   8.0   8.8  10.3  10.4
 495.6 746.71037.41396.31688.01868.11806.41643.51324.  977.  579.1 416.6
6   PHILIADELPHIA PA 39.88
  31.7  34.7  41.3  52.7  62.4  71.7  76.1  74.6  67.7  56.6  45.9  35.7
1031.4 875.7 733.5 380.2 134.8  12.9    .2   1.1  50.3 276.1 572.7 907.5
  10.3  11.0  11.5  11.1   9.7   8.8   8.1   8.0   8.4   8.9   9.5  10.1
 555.3 794. 11108.21433.91659.91811.21758.11574.51281.3 958.5 619.2 470.5
7   EAGLE    COLORADO 39.65
  17.3  23.0  31.6  41.4  51.6  60.2  65.9  63.1  54.6  43.4  29.3  18.0
1479.21188.31034.5 707.8 415.2 157.4  27.8  81.9 313.4 672.91070.01457.9
   4.7   5.1   6.6   7.5   7.0   6.7   5.5   5.2   5.4   5.0   4.7   4.1
 754.21078.51501.71932.62255.32508.92384.52083.81766.71307.2 868.6 690.9
```

```
8    KANSAS CITY    MO 39.12
  28.8  34.5  42.7  56.3  66.3  75.4  80.1  78.3  69.8  59.3  44.6  33.7
1125.0 663.6 692.6 289.6  87.3   6.7    .2    .9  47.3 228.2 612.4 971.6
  10.0  10.3  11.4  11.5  10.8   9.9   8.9   8.9   9.0   9.3  10.0  10.0
 647.9 694.41202.91575.11872.62079.62102.11862.41452.41092.3 737.2 561.5
9    OAKLAND    CALIF. 37.73
  48.3  51.7  53.1  55.3  58.0  61.0  61.8  62.4  63.4  60.4  54.6  49.1
 518.2 376.5 370.3 291.5 222.0 138.2 110.2  91.2  75.6 151.3 307.4 493.0
   6.8   7.4   9.1   9.7  10.1  10.0   9.4   9.1   8.0   6.9   6.5   6.7
 707.91017.41456.31922.12211.32350.02322.52052.61701.21212.0 822.2 647.0
10   BRYCE CANYON   UT 37.70
  19.5  23.2  29.1  37.6  47.5  56.9  63.2  60.6  52.7  42.1  29.6  21.2
1412. 1186. 1114.  821.4 542.0 249.0  76.9 144.4 370.0 710. 1060. 1358.6
   6.9   7.9   8.4   9.1   8.5   8.3   6.7   6.5   7.1   7.4   7.2   6.9
 914. 1236. 1685. 2133. 2454. 2655. 2424. 2157. 1920. 1465. 1016.  818.2
11   DODGE CITY    KAN 37.77
  29.2  34.0  41.2  53.7  64.0  74.0  79.0  77.5  67.9  57.1  41.7  32.4
1109.  875.3 739.2 354.7 128.2  15.4   1.4   1.9  70.9 275.4 701. 1011.7
  13.3  13.8  15.2  15.5  14.6  14.3  12.8  12.5  13.4  13.4  13.5  13.3
 827. 1122. 1477. 1886. 2070. 2358. 2296. 2055. 1687. 1301.  893.6 731.9
12   RICHMOND        VA 37.50
  36.9  39.4  46.6  57.7  65.8  73.3  76.9  75.5  69.0  58.0  48.4  39.6
 869.6 722.9 572.7 255.9  76.3   7.6    .0    .6  36.4 241.2 500.6 787.4
   7.9   8.7   9.0   8.9   7.9   7.2   6.7   6.3   6.6   6.8   7.3   7.5
 631.9 876. 1210.21566.01762.01872.41774.41600.61347.91032.7 733.  566.8
13   MONTEREY     CALIF 36.6
  51.4  52.9  52.9  53.9  55.9  58.3  59.4  60.6  62.2  60.6  56.4  52.3
 434.  336.  372.  333.  282.  201.  174.  136.   84.  136.  258.  394.
   5.0   5.3   6.3   6.8   7.2   7.1   6.5   6.1   5.1   4.6   4.2   4.4
 720.  980. 1410. 1930. 2210. 2320. 2240. 2020. 1650. 1180.  790.  620.
14   FRESNO       CALIF 36.77
  44.3  49.3  53.8  59.6  67.5  75.3  81.1  78.7  73.2  63.2  51.9  44.3
 640.7 442.4 349.7 187.0  55.6   5.3   0.0    .3   4.1 105.3 394.3 641.7
   5.3   5.7   6.7   7.2   7.9   8.0   7.0   6.5   5.8   5.2   4.8   5.0
 657. 1012. 1566. 2093. 2484. 2733. 2685. 2423. 1985. 1429.  888.6 574.1
15   TULSA   OKLAHOMA 36.20
  35.8  40.9  48.8  60.8  68.9  77.0  82.2  80.7  72.7  61.9  48.8  39.2
 906.7 681.3 513.7 180.3  45.0   1.8    .3    .1  21.5 163.0 490.8 799.9
  10.0  11.3  12.4  12.4  11.0  10.3   9.4   9.1   9.3  10.0  10.6  10.5
 732.  978. 1306. 1603. 1822. 2021. 2031. 1865. 1473. 1164.  827.4 659.3
16   NORFOLK VIRGINIA 36.90
  40.3  41.8  48.1  57.9  66.2  74.1  77.7  76.7  71.5  61.2  51.8  43.3
 764.4 655.4 527.5 248.0  71.7   4.9    .0    .1  10.1 153.5 403.0 671.9
  11.6  12.1  12.3  11.8  10.4   9.5   8.8   8.8   9.6  10.4  10.6  11.1
 679.6 931.41281. 1676.71887.52000.31853.21680.21395.61083.0 811.2 623.8
17   CARIBOU     MAINE 46.87
  11.4  13.8  24.6  37.1  50.1  60.9  65.4  62.6  54.5  43.4  31.6  16.7
1661.91445.61252.4 835.9 466.1 159.9  58.5 114.9 323.8 670. 1001.11497.9
```

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 11.7  11.7  12.4  11.5  11.3  10.6   9.7   9.5  10.1  10.7  10.9  11.3
 419.3 724. 1133.21414.31577.81757.41762.41500.61102.5 688.3 366.4 310.6
18  ADAK        ALASKA 51.88
 33.8  32.8  34.7  37.1  40.3  44.1  48.4  50.7  47.8  42.4  37.4  34.2
 967.9 909.5 940.3 836.8 765.2 628.3 514.9 443.0 516.6 701.5 828.0 953.9
 14.4  14.6  15.3  14.8  13.6  11.6  11.2  12.4  13.2  14.8  15.4  14.4
 231.2 432.5 716.41032.61179.61182.11120.4 948.6 759.3 528.2 307.9 187.2
19  PHEONIX   ARIZONA 33.43
 51.4  55.5  61.1  68.8  78.3  87.5  92.4  89.9  84.4  72.6  59.8  52.0
 422.0 272.0 156.8  35.6   3.1    .0    .0    .0    .2  17.3 172.0 404.5
  5.3   6.0   6.6   7.2   7.2   7.2   7.4   6.8   6.6   6.0   5.5   5.3
1021.31374.21814.12354.92676.52739.22486.52292.72015.51576.51150.5 932.0
20  POCATELLO   IDAHO 42.92
 24.5  29.2  35.1  44.1  54.7  63.0  72.2  69.7  59.3  47.7  35.4  26.5
1255.61014.9 926.6 626.5 330.4 129.5   9.2  30.0 195.9 538.2 889.01193.6
 11.1  11.1  11.6  12.0  10.6  10.5   9.3   9.2   9.3   9.3  10.4  10.4
 539.2 881.81371.51820.32280.32479.82599.82239.41769.31203.2 688.7 477.1
```

APPENDIX D

EXPERIMENT REPORT SUMMARIES

Each optimization problem or experiment is represented by an input summary report and an output summary report. These reports are tied together by a unique identification as follows:

$$\underline{L}\ \underline{L}\ \underline{N_1}\ \underline{N_2}\ \underline{N_3}$$

where,

LL = location identification number in accordance with Appendix C

N_1 = present worth factor identification number

- 1 - $F_i' = 18.22$
- 2 - $F_i' = 24.34$

N_2 = collector identification number

- 1 - Solarnetics
- 2 - American Sun
- 3 - Federal Prison Institute Double Glaze

N_3 = heat load conductance

- 1 - UA = 30000 Btu/HDD
- 2 - UA = 20000 Btu/HDD
- 3 - UA = 10000 Btu/HDD

The following report sets are included:

1111	2222	3111	4111
1112	2223	3112	4112
1113	2232	3213	4113
1213	2233	3222	4222
1223		3223	4223
1232		3232	4232
1233		3233	4233

9111	10111	11111	12111
9112	10112	11112	12112
9113	10112	11113	12113
9213	10213	11221	12221
9221	10221	11222	12222
9222	10222	11223	12223
9223	10223	11232	12232
9231	10231		
9232	10232		
	10233		

13111	14111	15111	16111
13112	14112	15112	16112
13223	14224	15223	16222
13232	14232	15232	16223
			16232

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* * * * * * * * * * * * * * * * * * * * * * * * * * *
*                                                   *
*                 S O L O A D - 1                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---          -            -        -            *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
              >>>>>DATA MATCH TO OUTPUT ID NO.  1111
                              IMOD-1 LWK AUGUST 1979


LOCATION       LACROSSE    WISC    COLLECTOR SOLARNETICS               STUDY APPROACH        ANALYSIS
--------                           -----------                         --------------

LOCATION INDEX......            1  COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....        43.87    SLOPE:                            ------------------
MEAN TEMPERATURE....        46.12    PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)      1160.56    INTERCEPT:                        SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....      6531.59    PARAMETER,FRTA....      0.6910    DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....        55.00  BASE COST,$/FT**2...       12.98    INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                            SELECTED PARAMETERS
----------------------------                            -------------------

TYPE ENERGY BASE..........................        OIL   COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........     134.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                        STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
-------------------------                               COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.25     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00     ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   30000.00     ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00     ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............       6.00     ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00     ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......       0.01
```

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACROSSE WISC

>>>>>DATA MATCH TO INPUT ID NO. 1111
OMCO-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.4608E 08	0.2637E 07	1088.7	1.841	0.017
FEB	764.5	1253.1	20.7	0.3759E 08	0.2382E 07	1537.6	1.584	0.034
MAR	1100.8	1055.6	31.0	0.3167E 08	0.2637E 07	2213.7	1.276	0.056
APR	1426.2	546.8	47.0	0.1640E 08	0.2552E 07	2947.9	1.055	0.110
MAY	1712.8	235.2	58.7	0.7056E 07	0.2637E 07	3507.0	0.934	0.235
JUN	1905.5	42.3	68.5	0.1269E 07	0.2552E 07	3757.0	0.886	0.541
JUL	1900.5	6.9	72.5	0.2070E 06	0.2637E 07	3641.9	0.908	0.701
AUG	1666.3	19.1	70.4	0.5730E 06	0.2637E 07	3178.5	1.007	0.627
SEP	1241.9	174.1	60.8	0.5223E 07	0.2552E 07	2486.2	1.186	0.252
OCT	863.5	444.3	50.9	0.1333E 08	0.2637E 07	1751.0	1.468	0.106
NOV	493.9	886.9	35.4	0.2661E 08	0.2552E 07	1193.9	1.713	0.028
DEC	369.5	331.2	22.1	0.9936E 07	0.2637E 07	959.2	1.856	0.035
TOTAL		6531.6		0.1959E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.086

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.987E 03
COLLECTOR TILT ANGLE (DEG) ....>>>	38.57	STORAGE SIDE CAPACITY (BTU/HR F).......	0.627E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0408	COLLECTOR SIDE CONVECTION COEFF.........	1321.7246
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0508	STORAGE SIDE CONVECTION COEFFICIENT	4248.0586
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1342	COLLECTOR SIDE FLOW RATE (GPM)	2.0237
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.4469	STORAGE SIDE FLOW RATE (GPM)	125.9017
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	23.1532	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
HEAT EXCHANGER LENGTH (FT)	66.29	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.2590
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9434
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0834	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.194E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.227E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.359E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.0855
STORAGE SIDE REYNOLDS NUMBER	0.273E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.199E 03
CAPACITY RATIO (CMIN/CMAX)..............	0.0157	HEX COEFFICIENT (BTU/HR F FT**2)........	337.16
FLOW PARAMETER Z2(GCP/FSUL).............	9.5992	TOTAL INSTALLATION COST ($)	3002.69
FLOW PARAMETER Z1(GCP/FPUL).............	9.00	COLLECTOR FLOW FACTOR(FPP)..............	0.9464

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*                                                     *
*                S O L O A D - 1                      *
*                                                     *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN      *
*                                                     *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY           *
*                                                     *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
               >>>>>DATA MATCH TO OUTPUT ID NO.  1112
                         IMJD-1 LWK AUGUST 1979


LOCATION      LACROSSE   WISC     COLLECTOR SOLARNETICS                       STUDY APPROACH          ANALYSIS
--------                          ---------                                   --------------

LOCATION INDEX......          1   COLLECTOR TEST RESULTS,                     ECONOMIC ESTIMATES
LATITUDE,DEGREES....      43.87     SLOPE:                                    ------------------
MEAN TEMPERATURE....      46.12     PARAMETER,FRUL....        1.0380
INSOL(BTU/DAY FT**2)    1160.56     INTERCEPT:                                SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....    6531.59     PARAMETER,FRTA....        0.6910          DISCOUNT RATE ......       0.1150
MEAN GROUND TEMP....      55.00   BASE COST,$/FT**2...       12.98            INFLATION RATE......       0.1050


ENERGY COMPARATIVE ESTIMATES                                  SELECTED PARAMETERS
----------------------------                                  -------------------

TYPE ENERGY BASE.............................OIL               COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE            COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL      0.70   0.90($/GAL)  142000.0(BTU/GAL)           COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2   ELE      0.99   0.05($/KWH)    3413.0(BTU/KWH)           COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3   GAS      0.70   0.40($/THM)  100000.0(BTU/THM)           STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                               STORAGE FLUID DENSITY(LB/FT**3).........        62.09
                                                               STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                                      STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                                      COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                               STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                               HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.17            ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00            ESTIMATED GROUND REFLECTANCE...........         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   20399.99            ESTIMATED PUMPING POWER(KWH/AREAC).....         1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00            ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00            ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............       0.00            ESTIMATED HEX COST ($/FT**2) ..........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00            ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                               MAINTENANCE (% INSTALLED COST/YR).......        0.01
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S O L C A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACROSSE WISC

>>>>>DATA MATCH TO INPUT ID NO. 1112
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.3134E 08	0.2637E 07	1088.7	1.846	0.024
FEB	764.5	1253.1	20.7	0.2556E 08	0.2382E 07	1537.6	1.587	0.048
MAR	1100.8	1055.6	31.0	0.2153E 08	0.2637E 07	2213.7	1.277	0.078
APR	1426.2	546.8	47.0	0.1115E 08	0.2552E 07	2947.9	1.054	0.149
MAY	1712.8	235.2	58.7	0.4798E 07	0.2637E 07	3507.0	0.932	0.297
JUN	1905.5	42.3	68.5	0.8629E 06	0.2552E 07	3757.0	0.884	0.587
JUL	1900.5	6.9	72.5	0.1408E 06	0.2637E 07	3641.9	0.906	0.710
AUG	1666.3	19.1	70.4	0.3896E 06	0.2637E 07	3178.5	1.005	0.652
SEP	1241.9	174.1	60.8	0.3552E 07	0.2552E 07	2486.2	1.185	0.312
OCT	863.5	444.3	50.9	0.9064E 07	0.2637E 07	1751.0	1.470	0.143
NOV	493.9	886.9	35.4	0.1809E 08	0.2552E 07	1193.9	1.716	0.039
DEC	369.5	331.2	22.1	0.6756E 07	0.2637E 07	959.2	1.861	0.048
TOTAL		6531.6		0.1332E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.116

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	38.91
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0361
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0461
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1260
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.4123
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	21.2084
HEAT EXCHANGER LENGTH (FT)	71.73
///////////////CONSTRAINTS//////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0799
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.406E 05
STORAGE SIDE REYNOLDS NUMBER	0.239E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0193
FLOW PARAMETER Z2(GCP/FRUL).............	9.5209
FLOW PARAMETER Z1(GCP/FFPUL)............	9.01

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.988E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.512E 05
COLLECTOR SIDE CONVECTION COEFF.........	1650.4468
STORAGE SIDE CONVECTION COEFFICIENT	4009.2195
COLLECTOR SIDE FLOW RATE (GPM)	2.0262
STORAGE SIDE FLOW RATE (GPM)	102.7698
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.0277
HEAT EXCHANGER EFFECTIVENESS............	0.9438
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.191E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.164E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1161
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.147E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	354.45
TOTAL INSTALLATION COST ($)	3000.53
COLLECTOR FLOW FACTOR(FPP)..............	0.9465

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                    S O L I A D - 1

       SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

            DESIGN DATA OPTIONS/INPUTS SUMMARY

                    >>>>>DATA MATCH TO OUTPUT ID NO.  1113
                                IMOD-1 LWK AUGUST 1979


LOCATION      LACROSSE   WISC     COLLECTOR SOLARNETICS                  STUDY APPROACH          ANALYSIS
--------                          ---------                              --------------

LOCATION INDEX......         1    COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....     43.87      SLOPE:                               ------------------
MEAN TEMPERATURE....     46.12      PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)   1160.56      INTERCEPT:                           SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....   6531.59      PARAMETER,FRTA....      0.6910       DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....     55.00    BASE COST,$/FT**2...     12.98         INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                    SELECTED PARAMETERS
----------------------------                    -------------------

TYPE ENERGY BASE..........................OIL   COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY   COST       HEATING VALUE COLLECTOR FLUID DENSITY(LB/FT**3).......     60.81
  1   OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL) COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).   1.0000
  2   ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH) COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)  0.3870
  3   GAS     0.70   0.40($/THM) 100000.0(BTU/THM) STORAGE FLUID MEAN TEMPERATURE ........   104.00
                                                STORAGE FLUID DENSITY(LB/FT**3).........      62.09
HEAT LOAD CHARACTERISTICS                       STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                       STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                HEX TUBE CONDUCTIVITY(BTU/HR FT F)......    220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..     0.09  ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....    15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..  5000.00  ESTIMATED GROUND REFLECTANCE...........,    0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........ 10799.99  ESTIMATED PUMPING POWER(KWH/AREAC)......    1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...   140.00  ESTIMATED CORRECTION FOR TAU ALPHA PROD.    0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...    20.00  ESTIMATED INSTALL/LABOR COST ($/AREAC)..   10.00
ESTIMATED DHW USERS (PEF)...............     6.00  ESTIMATED HEX COST ($/FT**2) ...........    5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.     1.00  ESTIMATED STORAGE TANK COST($/LB STORED)    0.08
                                                MAINTENANCE (% INSTALLED COST/YR).......      0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACROSSE WISC

>>>>>DATA MATCH TO INPUT ID NO. 1113
UMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.1659E 08	0.2637E 07	1088.7	1.853	0.043
FEB	764.5	1253.1	20.7	0.1353E 08	0.2382E 07	1537.6	1.591	0.083
MAR	1100.8	1055.6	31.0	0.1140E 08	0.2637E 07	2213.7	1.278	0.132
APR	1426.2	546.8	47.0	0.5905E 07	0.2552E 07	2947.9	1.052	0.232
MAY	1712.8	235.2	58.7	0.2540E 07	0.2637E 07	3507.0	0.930	0.402
JUN	1905.5	42.3	68.5	0.4568E 06	0.2552E 07	3757.0	0.881	0.635
JUL	1900.5	6.9	72.5	0.7452E 05	0.2637E 07	3641.9	0.903	0.719
AUG	1666.3	19.1	70.4	0.2063E 06	0.2637E 07	3178.5	1.003	0.678
SEP	1241.9	174.1	60.8	0.1880E 07	0.2552E 07	2486.2	1.185	0.408
OCT	863.5	444.3	50.9	0.4798E 07	0.2637E 07	1751.0	1.473	0.218
NOV	493.9	880.9	35.4	0.9579E 07	0.2552E 07	1193.9	1.722	0.066
DEC	369.5	331.2	22.1	0.3577E 07	0.2637E 07	959.2	1.869	0.072
TOTAL		6531.6		0.7054E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.182

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.990E 03
COLLECTOR TILT ANGLE (DEG) ....>>>	39.41	STORAGE SIDE CAPACITY (BTU/HR F)........	0.881E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0314	COLLECTOR SIDE CONVECTION COEFF.........	2129.5378
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0414	STORAGE SIDE CONVECTION COEFFICIENT	5139.9102
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1381	COLLECTOR SIDE FLOW RATE (GPM)	2.0307
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	5.8581	STORAGE SIDE FLOW RATE (GPM)	176.9727
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	28.9072	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
HEAT EXCHANGER LENGTH (FT)	76.05	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.7697
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9439
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0968	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.185E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.102E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.469E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1822
STORAGE SIDE REYNOLDS NUMBER	0.395E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.564E 02
CAPACITY RATIO (CMIN/CMAX)..............	0.0112	HEX COEFFICIENT (BTU/HR F FT**2)........	379.24
FLOW PARAMETER Z2(GCP/FRUL).............	9.5421	TOTAL INSTALLATION COST ($)	2997.26
FLOW PARAMETER Z1(GCP/FRPUL)............	9.03	COLLECTOR FLOW FACTOR(FPP)..............	0.9466

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                  S O L I A D - 1

   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
   ---          -            -        -
        DESIGN DATA OPTIONS/INPUTS SUMMARY

             >>>>>DATA MATCH TO OUTPUT ID NO. 1213
                            IMOD-1 LWK AUGUST 1979
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LOCATION        LACROSSE     WISC    COLLECTOR SOLARNETICS                    STUDY APPROACH          ANALYSIS
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LOCATION INDEX......            1    COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....        43.87      SLOPE:                                 ------------------
MEAN TEMPERATURE....        46.12        PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)      1160.56        INTERCEPT:                           SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....      6531.59        PARAMETER,FRTA....      0.6910       DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....        55.00    BASE COST,$/FT**2...         12.98       INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
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TYPE ENERGY BASE.......................         OIL       COLLECTOR FLUID MEAN TEMPERATURE........          176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE         COLLECTOR FLUID DENSITY(LB/FT**3).......           60.81
  1   OIL    0.70  0.90($/GAL) 142000.0(BTU/GAL)          COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).          1.0000
  2   ELE    0.99  0.05($/KWH)   3413.0(BTU/KWH)          COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)          0.3870
  3   GAS    0.70  0.40($/THM) 100000.0(BTU/THM)          STORAGE FLUID MEAN TEMPERATURE ........          134.00
                                                          STORAGE FLUID DENSITY(LB/FT**3)........           62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...          1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).          0.3640
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)             0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......          220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....           15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00    ESTIMATED GROUND REFLECTANCE...........,            0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........      10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......          1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.            0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...         20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..           10.00
ESTIMATED DHW USERS (PER)...............          6.00    ESTIMATED HEX COST ($/FT**2) ...........            5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.          1.00    ESTIMATED STORAGE TANK COST($/LB STORED)            0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......            0.00
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*                S I L O A D - 1                  *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
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*     RESULTS OF ANALYSIS FOR LACROSSE    WISC    *
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                  >>>>>DATA MATCH TO INPUT ID NO.  1213
                               JMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.1659E 08	0.2637E 07	1088.7	1.868	0.070
FEB	764.5	1253.1	20.7	0.1353E 08	0.2382E 07	1537.6	1.611	0.132
MAR	1100.8	1055.6	31.0	0.1140E 08	0.2637E 07	2213.7	1.280	0.264
APR	1426.2	546.8	47.0	0.5905E 07	0.2552E 07	2947.9	1.043	0.344
MAY	1712.8	235.2	58.7	0.2540E 07	0.2637E 07	3507.0	0.915	0.565
JUN	1905.5	42.3	68.5	0.4568E 06	0.2552E 07	3757.0	0.864	0.825
JUL	1900.5	6.9	72.5	0.7452E 05	0.2637E 07	3641.9	0.887	0.899
AUG	1666.3	19.1	70.4	0.2063E 06	0.2637E 07	3178.5	0.991	0.866
SEP	1241.9	174.1	60.8	0.1880E 07	0.2552E 07	2486.2	1.185	0.579
OCT	853.5	444.3	50.9	0.4798E 07	0.2637E 07	1751.0	1.486	0.331
NOV	493.9	886.9	35.4	0.9579E 07	0.2552E 07	1193.9	1.751	0.166
DEC	369.5	1331.2	22.1	0.1577E 08	0.2637E 07	959.2	1.906	0.120
TOTAL		6531.6		0.7054E 08	0.3105E 08			
							>>>WEIGHTED AVERAGE	0.262

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	159.72	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.160E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	42.11	STORAGE SIDE CAPACITY (BTU/HR F).......	0.352E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0593	COLLECTOR SIDE CONVECTION COEFF.........	989.3655
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0677	STORAGE SIDE CONVECTION COEFFICIENT	3574.7625
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1248	COLLECTOR SIDE FLOW RATE (GPM)	3.2720
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.6355	STORAGE SIDE FLOW RATE (GPM)	70.6953
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.2333	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
HEAT EXCHANGER LENGTH (FT)	70.43	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4426
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9130
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0571	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.266E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0084	TOTAL ENERGY DEMAND (BTU/YEAR)	0.102E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.399E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2616
STORAGE SIDE REYNOLDS NUMBER	0.147E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.164E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0453	HEX COEFFICIENT (BTU/HR F FT**2)........	305.46
FLOW PARAMETER Z2(GCP/FRPUL)............	9.6264	TOTAL INSTALLATION COST ($)	3931.48
FLOW PARAMETER Z1(GCP/FRPUL)............	9.12	COLLECTOR FLOW FACTOR(FPP)..............	0.9471

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*                    S O L I A C - 1                          *
*                                                             *
*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN             *
*                                                             *
*          DESIGN DATA OPTIONS/INPUTS SUMMARY                 *
*                                                             *
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                 >>>>>DATA MATCH TO OUTPUT ID NO.  1223
                                  IMOD-1 LWK AUGUST 1979
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LOCATION      LACROSSE     WISC     COLLECTOR AMERICAN SUN              STUDY APPROACH        ANALYSIS
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LOCATION INDEX......          1     COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....      43.87        SLOPE:                           ------------------
MEAN TEMPERATURE....      46.12        PARAMETER,FRUL....    1.0390
INSOL(BTU/DAY FT**2)    1160.56        INTERCEPT:                       SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....    6531.59        PARAMETER,FRTA....    0.6380     DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...       6.55     INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                             SELECTED PARAMETERS
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TYPE ENERGY BASE.........................        OIL     COLLECTOR FLUID MEAN TEMPERATURE........    176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE        COLLECTOR FLUID DENSITY(LB/FT**3).......     60.81
  1    OIL      0.70  0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).    1.0000
  2    ELE      0.99  0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)   0.3870
  3    GAS      0.70  0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE .........    104.00
                                                         STORAGE FLUID DENSITY(LB/FT**3).........     62.09
HEAT LOAD CHARACTERISTICS                                STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...    1.0000
-------------------------                                STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).    0.3640
                                                         COLLECTOR SIDE FOULING FACTOR(HR F/BTU)     0.0010
                                                         STORAGE SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......    220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....     15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00    ESTIMATED GROUND REFLECTANCE...........,      0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........     10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......    1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.      0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..     10.00
ESTIMATED DHW USERS (PER)...............         6.00    ESTIMATED HEX COST ($/FT**2) ..........       5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00    ESTIMATED STORAGE TANK COST($/LB STORED)      0.08
                                                         MAINTENANCE (% INSTALLED COST/YR).......    0.0010
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*              S O L O A D - 1                  *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
*   ---          -            -         -       *
*     RESULTS OF ANALYSIS FOR LACROSSE    WISC  *
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                 >>>>>DATA MATCH TO INPUT ID NO.  1223
                              OMCD-1 EWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.3	1536.1	15.4	0.1659E 08	0.2637E 07	1088.7	1.916	0.084
FEB	764.5	1253.1	20.7	0.1353E 08	0.2382E 07	1537.6	1.627	0.162
MAR	1100.3	1055.6	31.0	0.1140E 08	0.2637E 07	2213.7	1.281	0.248
APR	1426.2	546.8	47.0	0.5905E 07	0.2552E 07	2947.9	1.033	0.408
MAY	1712.8	235.2	58.7	0.2540E 07	0.2637E 07	3507.0	0.900	0.645
JUN	1905.5	42.3	68.5	0.4568E 06	0.2552E 07	3757.0	0.847	0.884
JUL	1900.5	6.9	72.5	0.7452E 05	0.2637E 07	3641.9	0.871	0.943
AUG	1666.3	19.1	70.4	0.2063E 06	0.2637E 07	3178.5	0.980	0.919
SEP	1241.9	174.1	60.8	0.1880E 07	0.2552E 07	2486.2	1.179	0.664
OCT	863.5	444.3	50.9	0.4798E 07	0.2637E 07	1751.0	1.496	0.398
NOV	495.9	386.9	35.4	0.9579E 07	0.2552E 07	1193.9	1.773	0.128
DEC	369.5	331.2	22.1	0.3577E 07	0.2637E 07	959.2	1.935	0.140
TOTAL		6531.6		0.7054E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.301

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	224.34
COLLECTOR TILT ANGLE (DEG) ....>>>	44.46
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0661
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0719
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1366
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1426
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.7016
HEAT EXCHANGER LENGTH (FT)	85.13
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0648
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0057
COLLECTOR SIDE REYNOLDS NUMBER..........	0.530E 05
STORAGE SIDE REYNOLDS NUMBER	0.189E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0481
FLOW PARAMETER Z2(GPM/FRUL).............	10.1093
FLOW PARAMETER Z1(GPM/FRUL).............	9.60

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.236E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.491E 05
COLLECTOR SIDE CONVECTION COEFF.........	1114.6167
STORAGE SIDE CONVECTION COEFFICIENT	3837.8962
COLLECTOR SIDE FLOW RATE (GPM)	4.8418
STORAGE SIDE FLOW RATE (GPM)	98.5827
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0215
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4385
HEAT EXCHANGER EFFECTIVENESS............	0.9007
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.306E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.102E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3014
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.229E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	317.83
TOTAL INSTALLATION COST ($)	4084.64
COLLECTOR FLOW FACTOR(FPP)..............	0.9497

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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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          >>>>>DATA MATCH TO OUTPUT ID NO.  1233
                       IMCD-1 LWK AUGUST 1979


LOCATION     LACROSSE    WISC     COLLECTOR FEDERAL PRISON I. D      STUDY APPROACH         ANALYSIS

LOCATION INDEX......          1   COLLECTOR TEST RESULTS,            ECONOMIC ESTIMATES
LATITUDE,DEGREES....      43.87     SLOPE:
MEAN TEMPERATURE....      46.12     PARAMETER,FRUL....     0.8830
INSOL(BTU/DAY FT**2)    1160.56     INTERCEPT:                       SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....    6531.59     PARAMETER,FRTA....     0.6270    DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....      55.00   BASE COST,$/FT**2...       9.40    INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                           SELECTED PARAMETERS

TYPE ENERGY BASE............................ OIL     COLLECTOR FLUID MEAN TEMPERATURE.........    176.0
INDEX TYPE EFFICIENCY   COST       HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3)........     60.8
  1   OIL    0.70  0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).    1.000
  2   ELE    0.99  0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)   0.387
  3   GAS    0.70  0.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE .........    104.0
                                                     STORAGE FLUID DENSITY(LB/FT**3).........     62.0
HEAT LOAD CHARACTERISTICS                            STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...    1.000
                                                     STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).    0.364
                                                     COLLECTOR SIDE FOULING FACTOR(HR F/BTU)     0.001
                                                     STORAGE SIDE FOULING FACTOR(HR F/BTU)       0.001
                                                     HEX TUBE CONDUCTIVITY(BTU/HR FT F)......    220.0
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.99   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....     15.3
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00   ESTIMATED GROUND REFLECTANCE...........,      0.2
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99   ESTIMATED PUMPING POWER(KWH/AREAC)......    1.000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.      0.9
ESTIMATED DAILY DHW USAGE (GAL/PER) ...      20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..     10.0
ESTIMATED DHW USERS (PER)...............      6.00   ESTIMATED HEX COST ($/FT**2) ...........      5.0
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00   ESTIMATED STORAGE TANK COST($/LB STORED)      0.0
                                                     MAINTENANCE (% INSTALLED COST/YR).......    0.001
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*                                                   *
*              S O L O A D - 1                      *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*                                                   *
*      RESULTS OF ANALYSIS FOR LACROSSE    WISC     *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                     >>>>>DATA MATCH TO INPUT ID NO.  1233
                                 MOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	431.3	1536.1	15.4	0.1659E 08	0.2637E 07	1088.7	1.897	0.085
FEB	764.5	1253.1	20.7	0.1353E 08	0.2382E 07	1537.6	1.616	0.155
MAR	1100.8	1055.6	31.0	0.1140E 08	0.2637E 07	2213.7	1.281	0.236
APR	1426.2	546.8	47.0	0.5905E 07	0.2552E 07	2947.9	1.040	0.392
MAY	1712.8	235.2	58.7	0.2540E 07	0.2637E 07	3507.0	0.910	0.629
JUN	1905.5	42.3	68.5	0.4568E 06	0.2552E 07	3757.0	0.859	0.889
JUL	1900.5	6.9	72.5	0.7452E 05	0.2637E 07	3641.9	0.882	0.957
AUG	1666.3	19.1	70.4	0.2063E 06	0.2637E 07	3178.5	0.986	0.927
SEP	1241.0	174.1	60.8	0.1880E 07	0.2552E 07	2486.2	1.182	0.646
OCT	863.5	444.3	50.9	0.4798E 07	0.2637E 07	1751.0	1.490	0.380
NOV	473.9	886.9	35.4	0.9579E 07	0.2552E 07	1193.9	1.757	0.123
DEC	369.5	331.2	22.1	0.3577E 07	0.2637E 07	959.2	1.915	0.151
TOTAL		6531.6		0.7054E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.296

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	201.32
COLLECTOR TILT ANGLE (DEG) ....>>>	42.81
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0587
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0637
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1241
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.9194
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.3141
HEAT EXCHANGER LENGTH (FT)	66.42
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0604
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.437E 05
STORAGE SIDE REYNOLDS NUMBER	0.152E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0487
FLOW PARAMETER Z2(GCP/LROUL)............	9.7272
FLOW PARAMETER Z1(GCP/FPRUL)............	9.22

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.173E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.355E 05
COLLECTOR SIDE CONVECTION COEFF.........	1076.1470
STORAGE SIDE CONVECTION COEFFICIENT	3493.5629
COLLECTOR SIDE FLOW RATE (GPM)	3.5452
STORAGE SIDE FLOW RATE (GPM)	71.2998
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0176
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3542
HEAT EXCHANGER EFFECTIVENESS............	0.8832
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.301E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.102E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2960
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.207E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	312.12
TOTAL INSTALLATION COST ($)	4213.31
COLLECTOR FLOW FACTOR(FRP)..............	0.9477

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                    S O L T A C - 1

   SOLAR ENERGY OPTIMIZATION ANALYSIS ON DESIGN
          DESIGN DATA OPTIONS/INPUTS SUMMARY

                        >>>>>DATA MATCH TO OUTPUT ID NO.  1232
                                       IMOD-1 LWK AUGUST 1979
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LOCATION	LACROSSE WISC
LOCATION INDEX.......	1
LATITUDE,DEGREES.....	43.87
MEAN TEMPERATURE.....	46.12
INSOL(BTU/DAY FT**2)	1160.56
LOAD FACTOR,HLL......	6531.59
MEAN GROUND TEMP.....	55.00

COLLECTOR FEDERAL PRISON I. C	
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL	0.8830
INTERCEPT:	
PARAMETER,FRTA....	0.6270
BASE COST,$/FT**2...	9.40

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0700
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE............................				OIL
INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	20359.39
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW UPTAKE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	6.00
ESTIMATED THERMAL LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3)........	60.31
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3370
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3)..........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............,	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.	0.95
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	1.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.010

S I L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR LACROSSE WISC

\>\>\>\>\>DATA MATCH TO INPUT ID NO. 1232
INOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	481.5	1536.1	15.4	0.5134E 08	0.2637E 07	1088.7	1.915	0.062
FEB	764.5	1253.1	20.7	0.2556E 08	0.2382E 07	1537.6	1.526	0.114
MAR	1100.8	1055.6	31.0	0.2153E 08	0.2637E 07	2213.7	1.281	0.177
APR	1426.2	546.8	47.0	0.1115E 08	0.2552E 07	2947.9	1.034	0.313
MAY	1712.3	235.2	58.7	0.4798E 07	0.2637E 07	3507.0	0.901	0.566
JUN	1905.5	42.3	68.5	0.8520E 06	0.2552E 07	3757.0	0.848	0.916
JUL	1900.5	6.9	72.5	0.1408E 06	0.2637E 07	3641.9	0.872	1.000
AUG	1666.3	19.1	70.4	0.3896E 06	0.2637E 07	3178.5	0.960	0.970
SEP	1241.9	174.1	60.8	0.3552E 07	0.2552E 07	2486.2	1.179	0.605
OCT	865.5	444.3	50.9	0.9064E 07	0.2637E 07	1751.0	1.496	0.316
NOV	493.5	886.9	35.4	0.1809E 08	0.2552E 07	1193.9	1.772	0.097
DEC	369.5	331.2	22.1	0.6756E 07	0.2637E 07	959.2	1.934	0.129
TOTAL		6531.6		0.1332E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.228

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	252.23
COLLECTOR TILT ANGLE (DEG) ....>>>	44.35
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0520
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0634
STORAGE SIDE PIPE(HEX) INNER DIA. (FT)..	0.1295
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2536
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.5484
HEAT EXCHANGER LENGTH (FT)	76.89
///////////////////CONSTRAINTS///////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0612
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0064
COLLECTOR SIDE REYNOLDS NUMBER	0.514E 05
STORAGE SIDE REYNOLDS NUMBER	0.160E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0545
FLOW PARAMETER Z2(GPM/FOUL).............	9.6456
FLOW PARAMETER Z1(GPM/FRPUL)............	9.13

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.2151 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.3946 05
COLLECTOR SIDE CONVECTION COEFF..........	1160.9509
STORAGE SIDE CONVECTION COEFFICIENT	5591.0862
COLLECTOR SIDE FLOW RATE (GPM)	4.4035
STORAGE SIDE FLOW RATE (GPM)	79.1367
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0175
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3137
HEAT EXCHANGER EFFECTIVENESS.............	0.8842
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.375E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.164E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2284
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.[illegible]E 04
HEX COEFFICIENT (BTU/HR F FT**2).........	315.73
TOTAL INSTALLATION COST ($)	5276.79
COLLECTOR FLOW FACTOR(FPP)................	0.9472

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                    S O L O A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

          DESIGN DATA OPTIONS/INPUTS SUMMARY

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               >>>>>DATA MATCH TO OUTPUT ID NO.  2222
                                 IMCD-I LWK AUGUST 1979


LOCATION      SHERIDAN WYOMING       COLLECTOR AMERICAN SUN              STUDY APPROACH         ANALYSIS

LOCATION INDEX......           2     COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....       44.77       SLOPE:
MEAN TEMPERATURE....       45.18         PARAMETER,FRUL....    1.0390
INSOL(BTU/DAY FT**2)     1330.10       INTERCEPT:                        SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....     7666.83         PARAMETER,FRTA....    0.6380    DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....       55.00     BASE COST,$/FT**2...        6.55    INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS

TYPE ENERGY BASE.......................... OIL               COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY     COST          HEATING VALUE        COLLECTOR FLUID DENSITY(LB/FT**3).......      60.61
  1   OIL      0.70   0.50($/GAL) 142000.0(BTU/GAL)          COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2   ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)          COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3370
  3   GAS      0.70   0.40($/THM) 100000.0(BTU/THM)          STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
                                                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.17       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00       ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........      20399.99       ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00       ESTIMATED CORRECTION FOR TAU ALPHA PROD.       0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...          20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............          6.00       ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.          1.00       ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......     0.0010
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S J L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

RESULTS OF ANALYSIS FOR SHERIDAN WYOMING

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>>>>>DATA MATCH TO INPUT ID NO. 2222
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1364.0	21.0	0.2733E 08	0.2637E 07	1042.0	2.127	0.166
FEB	783.3	1083.0	26.7	0.2209E 08	0.2382E 07	1492.4	1.722	0.261
MAR	1204.8	1012.0	32.4	0.2064E 08	0.2637E 07	2175.8	1.324	0.373
APR	1537.2	661.4	43.0	0.1349E 08	0.2552E 07	2923.7	1.023	0.491
MAY	1882.7	359.7	53.6	0.7338E 07	0.2637E 07	3497.7	0.868	0.730
JUN	2156.0	127.6	62.6	0.2603E 07	0.2552E 07	3755.8	0.807	0.967
JUL	2325.0	17.3	70.8	0.3529E 06	0.2637E 07	3636.8	0.833	1.000
AUG	2005.0	34.3	69.5	0.6997E 06	0.2637E 07	3159.9	0.967	1.000
SEP	1502.0	241.8	57.8	0.4953E 07	0.2552E 07	2452.5	1.222	0.903
OCT	1005.3	562.0	46.9	0.1146E 08	0.2637E 07	1707.5	1.620	0.578
NOV	591.0	973.0	32.6	0.1785E 08	0.2552E 07	1147.3	2.030	0.255
DEC	441.4	1230.8	25.3	0.2511E 08	0.2637E 07	912.6	2.279	0.157
TOTAL		7666.9		0.1554E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.382

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	496.07	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.490E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	50.28	STORAGE SIDE CAPACITY (BTU/HR F)........	0.880E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0390	COLLECTOR SIDE CONVECTION COEFF..........	1169.5313
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0958	STORAGE SIDE CONVECTION COEFFICIENT	4105.9375
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1752	COLLECTOR SIDE FLOW RATE (GPM)	10.0486
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.5952	STORAGE SIDE FLOW RATE (GPM)	176.6272
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	23.2528	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
HEAT EXCHANGER LENGTH (FT)	140.99	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3561
//////////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS..............	0.9185
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0794	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.716E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0058	TOTAL ENERGY DEMAND (BTU/YEAR)	0.187E 09
COLLECTOR SIDE REYNOLDS NUMBER...........	0.317E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3820
STORAGE SIDE REYNOLDS NUMBER	0.261E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.594E 04
CAPACITY RATIO (CMIN/CMAX)...............	0.0557	HEX COEFFICIENT (BTU/HR F FT**2)........	322.97
FLOW PARAMETER Z2(GPP/FRUL)..............	9.5092	TOTAL INSTALLATION COST ($)	[illegible]014.31
FLOW PARAMETER Z1(GCP/FRPUL).............	9.00	COLLECTOR FLOW FACTOR(FPP)...............	0.9404

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*                  S O L U A D - 1                           *
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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN            *
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*           DESIGN DATA OPTIONS/INPUTS SUMMARY               *
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                 >>>>>DATA MATCH PD OUTPUT ID NO.  2223
                                IMCD-1 LVK AUGUST 1979


LOCATION        SHERIDAN WYOMING      COLLECTOR AMERICAN SUN               STUDY APPROACH            ANALYSIS
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LOCATION INDEX......          2       COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      44.77         SLOPE:                             ------------------
MEAN TEMPERATURE....      45.18         PARAMETER,FRUL....     1.0390
INSOL(BTU/DAY FT**2)    1330.10         INTERCEPT:                         SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....    7666.88         PARAMETER,FRTA....     0.6380      DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....      55.00       BASE COST,$/FT**2...       6.55      INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
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TYPE ENERGY BASE.........................   OIL       COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY    COST        HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1    OIL    0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2    ELE    0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS    0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........        62.09
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00    ESTIMATED GROUND REFLECTANCE...........,         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00    ESTIMATED CORRECTION FOR TAU ALPHA PROD.         0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...      20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............      6.00    ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00    ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......       0.0010
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SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SHERIDAN WYOMING

\>>>>>DATA MATCH TO INPUT ID NO. 2223
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1364.0	21.0	0.1473E 08	0.2637E 07	1042.0	2.124	0.178
FEB	788.3	1083.0	26.7	0.1170E 08	0.2382E 07	1492.4	1.720	0.277
MAR	1204.8	1012.0	32.4	0.1093E 08	0.2637E 07	2175.8	1.324	0.391
APR	1537.2	661.4	43.0	0.7143E 07	0.2552E 07	2923.7	1.024	0.459
MAY	1882.7	359.7	53.6	0.3885E 07	0.2637E 07	3497.7	0.870	0.707
JUN	2156.0	127.6	62.6	0.1378E 07	0.2552E 07	3755.8	0.808	0.927
JUL	2329.0	17.3	70.8	0.1868E 06	0.2637E 07	3636.8	0.835	1.000
AUG	2006.0	34.3	69.5	0.3704E 06	0.2637E 07	3159.9	0.969	1.000
SEP	1502.0	241.8	57.8	0.2611E 07	0.2552E 07	2452.5	1.222	0.866
OCT	1005.3	562.0	46.9	0.6070E 07	0.2637E 07	1707.5	1.619	0.577
NOV	591.0	973.0	32.6	0.1051E 08	0.2552E 07	1147.3	2.028	0.267
DEC	441.4	1230.8	25.3	0.1329E 08	0.2637E 07	912.6	2.277	0.167
TOTAL		7666.9		0.8280E 08	0.3105E 08			

\>>>WEIGHTED AVERAGE 0.411

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	308.46	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.311E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	50.06	STORAGE SIDE CAPACITY (BTU/HR F).......	0.447E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0759	COLLECTOR SIDE CONVECTION COEFF.........	1084.3394
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0809	STORAGE SIDE CONVECTION COEFFICIENT	3666.0127
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1408	COLLECTOR SIDE FLOW RATE (GPM)	6.3855
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1431	STORAGE SIDE FLOW RATE (GPM)	89.6845
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.1529	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0207
HEAT EXCHANGER LENGTH (FT)	79.96	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2908
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8422
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0599	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.468E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 09
COLLECTOR SIDE REYNOLDS NUMBER...........	0.607E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4115
STORAGE SIDE REYNOLDS NUMBER	0.162E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.423E 04
CAPACITY RATIO (CMIN/CMAX)...............	0.0697	HEX COEFFICIENT (BTU/HR F FT**2)........	313.56
FLOW PARAMETER Z2(SCP/FRUL).............	9.7182	TOTAL INSTALLATION COST ($)	5577.83
FLOW PARAMETER Z1(CCP/FRUL).............	9.21	COLLECTOR FLOW FACTOR(FPP)..............	0.9476

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*                         S O L A R - L                                  *
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*     SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN                        *
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*            DESIGN DATA OPTIONS/INPUTS SUMMARY                           *
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              >>>>>DATA MATCH TO OUTPUT ID NO.   2232
                              LMOD-1 LWK AUGUST 1979


LOCATION       SHERIDAN WYOMING      COLLECTOR FEDERAL PRISM I. D        STUDY APPROACH          ANALYSIS
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LOCATION INDEX......          2      COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....      44.77        SLOPE:                            ------------------
MEAN TEMPERATURE....      45.18        PARAMETER,FRUL....    0.8830
INSOL(BTU/DAY FT**2)    1330.16        INTERCEPT:                        SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....    7666.88        PARAMETER,FRTA....    0.6270      DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....      55.00      BASE COST,$/FT**2...      9.40      INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
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TYPE ENERGY BASE.........................     OIL     COLLECTOR FLUID MEAN TEMPERATURE.........   170.00
INDEX TYPE EFFICIENCY    COST         HEATING VALUE   COLLECTOR FLUID DENSITY(LB/FT**3)........    60.81
  1    OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)  COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).   1.0000
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)  COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)   0.3670
  3    GAS     0.70   0.40($/THM)  100000.0(BTU/THM)  STORAGE FLUID MEAN TEMPERATURE .........   104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3)..........    62.09
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...   1.0000
-------------------------                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).   0.3640
                                                      COLLECTOR SIDE FOULING FACTOR(HR F/BTU)    0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F).......   220.00
LOAD LOSS COEFFICIENT (BTU/H F FT**2)..      0.17     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....    15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..  5000.00     ESTIMATED GROUND REFLECTANCE............     0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........ 20399.99     ESTIMATED PUMPING POWER(KWH/AREAC)......   1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...   140.00     ESTIMATED CORRECTION FOR TAU ALPHA PRED.     0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...    20.00     ESTIMATED INSTALL/LAREA COST ($/AREAC)..    10.00
ESTIMATED DHW USERS (PER)...............     6.00     ESTIMATED HEX COST ($/FT**2) ...........     5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.     1.00     ESTIMATED STORAGE TANK COST($/LB STORED)     0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......   0.0010
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SOLAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SHERIDAN WYOMING

\>>>>>DATA MATCH TO INPUT ID NO. 2252
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1364.0	21.0	0.2783E 08	0.2637E 07	1042.0	2.122	0.152
FEB	788.3	1083.0	26.7	0.2209E 08	0.2382E 07	1492.4	1.719	0.234
MAR	1204.8	1012.0	32.4	0.2064E 08	0.2637E 07	2175.8	1.324	0.333
APR	1537.2	661.4	43.0	0.1349E 08	0.2552E 07	2923.7	1.026	0.444
MAY	1862.7	359.7	53.6	0.7338E 07	0.2637E 07	3457.7	0.872	0.681
JUN	2156.0	127.6	62.6	0.2603E 07	0.2552E 07	3755.8	0.811	0.972
JUL	2379.0	17.3	70.8	0.3529E 06	0.2637E 07	3636.8	0.837	1.000
AUG	2066.0	34.3	69.5	0.6997E 06	0.2637E 07	3159.9	0.970	1.000
SEP	1502.0	241.8	57.8	0.4933E 07	0.2552E 07	2452.5	1.223	0.869
OCT	1006.0	562.0	46.9	0.1146E 08	0.2637E 07	1707.5	1.619	0.525
NOV	591.0	973.0	32.6	0.1985E 08	0.2552E 07	1147.3	2.026	0.230
DEC	441.4	1230.8	25.3	0.2511E 08	0.2637E 07	912.6	2.273	0.146
TOTAL		7666.9		0.1564E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.355

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	417.36	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.353E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	49.78	STORAGE SIDE CAPACITY (BTU/HR F).......	0.179E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0784	COLLECTOR SIDE CONVECTION COEFF.........	1131.1619
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0834	STORAGE SIDE CONVECTION COEFFICIENT	3639.2209
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1450	COLLECTOR SIDE FLOW RATE (GPM)	7.2395
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3405	STORAGE SIDE FLOW RATE (GPM)	96.2462
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.4225	NORMALIZED COLLECTOR FLOW (GPM/AREA)...	0.0173
HEAT EXCHANGER LENGTH (FT)	76.33	NORMALIZED STORAGE FLOW (GPM/AREA) ...	0.2306
////////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.8035
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0516	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.665E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.187E 09
COLLECTOR SIDE REYNOLDS NUMBER...........	0.668E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3546
STORAGE SIDE REYNOLDS NUMBER	0.162E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.523E 04
CAPACITY RATIO (CMIN/CMAX)...............	0.0737	HEX COEFFICIENT (BTU/HR F FT**2)........	317.47
FLOW PARAMETER Z2(UCP/F-OL).............	9.5314	TOTAL INSTALLATION COST ($)	8701.65
FLOW PARAMETER Z1(GCP/FRPUL).............	9.07	COLLECTOR FLOW FACTOR(FPP)..............	0.9469

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*                  S O L J A D - 1                  *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN     *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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                    >>>>>DATA MATCH TO OUTPUT ID NO.  2233
                                  IMID-I LWK AUGUST 1979
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LOCATION	SHERIDAN WYOMING
LOCATION INDEX......	2
LATITUDE,DEGREES....	44.77
MEAN TEMPERATURE....	45.18
INSOL(BTU/DAY FT**2)	1330.16
LOAD FACTOR,HDD.....	7666.38
MEAN GROUND TEMP....	55.00

COLLECTOR	FEDERAL PRISON I. D
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	0.8830
INTERCEPT:	
PARAMETER,FRTA....	0.6270
BASE COST,$/FT**2...	9.40

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE........................ OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.50($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.09
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	10799.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	0.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.0
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.387
STORAGE FLUID MEAN TEMPERATURE	104.0
STORAGE FLUID DENSITY(LB/FT**3).........	62.0
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.364
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.001
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.001
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.0
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.3
ESTIMATED GROUND REFLECTANCE............,	0.2
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.	0.9
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.0
ESTIMATED HEX COST ($/FT**2)	5.0
ESTIMATED STORAGE TANK COST($/LB STORED)	0.0
MAINTENANCE (% INSTALLED COST/YR).......	0.001

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SHERIDAN WYOMING

>>>>>DATA MATCH TO INPUT ID NO. 2253
OMED-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	517.5	1364.0	21.0	0.1473E 08	0.2637E 07	1042.0	2.115	0.178
FEB	788.3	1083.0	26.7	0.1170E 08	0.2382E 07	1492.4	1.716	0.270
MAR	1204.8	1012.0	32.4	0.1093E 08	0.2637E 07	2175.8	1.325	0.375
APR	1537.2	661.4	43.0	0.7143E 07	0.2552E 07	2923.7	1.029	0.488
MAY	1832.7	359.7	53.6	0.3885E 07	0.2637E 07	3497.7	0.876	0.701
JUN	2156.0	127.6	62.6	0.1378E 07	0.2552E 07	3755.8	0.815	0.943
JUL	2329.0	17.3	70.8	0.1868E 06	0.2637E 07	3636.8	0.841	1.000
AUG	2006.0	34.3	69.5	0.3704E 06	0.2637E 07	3159.9	0.974	1.000
SEP	1502.0	241.8	57.8	0.2611E 07	0.2552E 07	2452.5	1.225	0.864
OCT	1006.0	562.0	46.9	0.6070E 07	0.2637E 07	1707.5	1.617	0.563
NOV	591.0	973.0	32.6	0.1051E 08	0.2552E 07	1147.3	2.020	0.263
DEC	441.4	1230.8	25.3	0.1329E 08	0.2637E 07	912.6	2.265	0.169
TOTAL		7666.9		0.8280E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.407

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	279.68
COLLECTOR TILT ANGLE (DEG) ....>>>	49.22
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0635
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0706
STORAGE SIDE TUBE(HLX) INNER DIA. (FT)..	0.1379
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.4242
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.2742
HEAT EXCHANGER LENGTH (FT)	59.53
///////////////////CONSTRAINTS///////////////////	
HLX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0673
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0071
COLLECTOR SIDE REYNOLDS NUMBER	0.555E 05
STORAGE SIDE REYNOLDS NUMBER	0.193E 06
CAPACITY RATIO ((CMIN/CMAX)...............	0.0476
FLOW PARAMETER Z2(GCP/FPUL)..............	9.6112
FLOW PARAMETER Z1(GCP/FRPUL).............	9.10

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.237E 04
STORAGE SIDE CAPACITY (BTU/HR F).........	0.499E 05
COLLECTOR SIDE CONVECTION COEFF...........	1203.5054
STORAGE SIDE CONVECTION COEFFICIENT	3802.6697
COLLECTOR SIDE FLOW RATE (GPM)	4.8664
STORAGE SIDE FLOW RATE (GPM)	100.2001
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0174
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3583
HEAT EXCHANGER EFFECTIVENESS.............	0.9064
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.464E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4073
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.388E 04
HLX COEFFICIENT (BTU/HR F FT**2).........	324.58
TOTAL INSTALLATION COST ($)	5857.43
COLLECTOR FLOW FACTOR(FRP)...............	0.9470

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*                 S O L O A D - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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                  >>>>>DATA MATCH TO OUTPUT ID NO.  3111
                                 IMOC-1 LWK AUGUST 1979


LOCATION        SALEM      OREGON     COLLECTOR SOLARNETICS                        STUDY APPROACH        ANALYSIS
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LOCATION INDEX.......            3    COLLECTOR TEST RESULTS,                       ECONOMIC ESTIMATES
LATITUDE,DEGREES....         44.92      SLOPE:                                     ------------------
MEAN TEMPERATURE....         51.75      PARAMETER,FRUL....          1.0380
INSOL(BTU/DAY FT**2)       1126.63      INTERCEPT:                                 SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....       5017.00      PARAMETER,FRTA....          0.6910         DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....         55.00    BASE COST,$/FT**2...           12.98         INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS
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TYPE ENERGY BASE..........................        OIL   COLLECTOR FLUID MEAN TEMPERATURE........         176.00
INDEX TYPE EFFICIENCY   COST           HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......          60.81
  1   OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).         1.0000
  2   ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)     COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)         0.3870
  3   GAS     0.70   0.40($/THM)  100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........          104.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........          62.09
                                                        STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...         1.0000
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).         0.3640
-------------------------                               COLLECTOR SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)            0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......         220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.25     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....          15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00     ESTIMATED GROUND REFLECTANCE...........,           0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   30000.00     ESTIMATED PUMPING POWER(KWH/AREAC)......         1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00     ESTIMATED CORRECTION FOR TAL ALPHA PRED.           0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..          10.00
ESTIMATED DHW USERS (PER)...............       6.00     ESTIMATED HEX COST ($/FT**2) ...........           5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00     ESTIMATED STORAGE TANK COST($/LB STORED)           0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......           0.01
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*               S O L O A D - 1                 *
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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
*    ---          -            -          -     *
*      RESULTS OF ANALYSIS FOR SALEM     OREGON *
*                                               *
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                   >>>>>DATA MATCH TO INPUT ID NO.  3111
                               JMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.2350E 08	0.2637E 07	1034.2	1.602	0.009
FEB	588.0	642.5	42.3	0.1927E 08	0.2382E 07	1484.8	1.473	0.038
MAR	947.1	638.9	44.4	0.1917E 08	0.2637E 07	2169.4	1.250	0.070
APR	1370.4	493.6	48.6	0.1481E 08	0.2552E 07	2919.6	1.071	0.116
MAY	1737.8	316.2	54.9	0.9486E 07	0.2637E 07	3496.1	0.962	0.200
JUN	1841.6	154.7	60.6	0.4641E 07	0.2552E 07	3755.5	0.917	0.318
JUL	2142.4	46.2	66.2	0.1386E 07	0.2637E 07	3635.9	0.938	0.632
AUG	1774.7	50.1	65.4	0.1503E 07	0.2637E 07	3156.7	1.034	0.566
SEP	1328.3	140.6	61.0	0.4218E 07	0.2552E 07	2446.9	1.210	0.317
OCT	769.4	397.1	52.2	0.1191E 08	0.2637E 07	1700.3	1.431	0.095
NOV	410.4	605.6	44.8	0.1817E 08	0.2552E 07	1139.5	1.611	0.024
DEC	277.4	748.0	40.9	0.2244E 08	0.2637E 07	904.9	1.656	0.003
TOTAL		5017.0		0.1505E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.101

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	34.21
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0261
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0361
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1394
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	8.4222
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	34.2500
HEAT EXCHANGER LENGTH (FT)	89.82
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.1032
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.562E 05
STORAGE SIDE REYNOLDS NUMBER	0.499E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0091
FLOW PARAMETER Z2(GCP/FRUL).............	9.5301
FLOW PARAMETER Z1(GCP/FRPUL)............	9.02

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.989E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.109E 06
COLLECTOR SIDE CONVECTION COEFF.........	2952.8518
STORAGE SIDE CONVECTION COEFFICIENT	5977.3281
COLLECTOR SIDE FLOW RATE (GPM)	2.0281
STORAGE SIDE FLOW RATE (GPM)	218.7775
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	2.1878
HEAT EXCHANGER EFFECTIVENESS............	0.9497
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.183E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.182E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1008
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.214E 02
HEX COEFFICIENT (BTU/HR F FT**2)........	403.40
TOTAL INSTALLATION COST ($)	2996.05
COLLECTOR FLOW FACTOR(FPP)..............	0.9466

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*                                                                *
*                     S O L O A D - 1                            *
*                                                                *
*     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN               *
*                                                                *
*          DESIGN DATA OPTIONS/INPUTS SUMMARY                    *
*                                                                *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                 >>>>>DATA MATCH TO OUTPUT ID NO.  3112
                                 IMOD-I LWK AUGUST 1979


LOCATION        SALEM       OREGON     COLLECTOR SOLARNETICS                      STUDY APPROACH          ANALYSIS
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LOCATION INDEX......            3      COLLECTOR TEST RESULTS,                    ECONOMIC ESTIMATES
LATITUDE,DEGREES....        44.92        SLOPE:                                   ------------------
MEAN TEMPERATURE....        51.75         PARAMETER,FRUL ....      1.0380
INSOL(BTU/DAY FT**2)      1126.63        INTERCEPT:                               SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....      5017.00         PARAMETER,FRTA....       0.6910         DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....        55.00      BASE COST,$/FT**2...        12.98          INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                           SELECTED PARAMETERS
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TYPE ENERGY BASE..........................   OIL   COLLECTOR FLUID MEAN TEMPERATURE........         176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......          60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)  COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).         1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)  COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)        0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)  STORAGE FLUID MEAN TEMPERATURE ........         104.00
                                                     STORAGE FLUID DENSITY(LB/FT**3).........          62.09
                                                     STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...         1.0000
HEAT LOAD CHARACTERISTICS                            STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).         0.3640
-------------------------                            COLLECTOR SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                     STORAGE SIDE FOULING FACTOR(HR F/BTU)            0.0010
                                                     HEX TUBE CONDUCTIVITY(BTU/HR FT F)......         220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.17   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....          15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00   ESTIMATED GROUND REFLECTANCE...........,           0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  20399.99   ESTIMATED PUMPING POWER(KWH/AREAC)......         1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00   ESTIMATED CORRECTION FOR TAU ALPHA PROD.           0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..          10.00
ESTIMATED DHW USERS (PER)...............      6.00   ESTIMATED HEX COST ($/FT**2) ...........           5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00   ESTIMATED STORAGE TANK COST($/LB STORED)           0.08
                                                     MAINTENANCE (% INSTALLED COST/YR).......           0.01
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*                 S O L O A D - 1                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---          -            -           -         *
*     RESULTS OF ANALYSIS FOR SALEM      OREGON     *
*                                                   *
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                 >>>>>DATA MATCH TO INPUT ID NO.  3112
                                 MOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.1598E 08	0.2637E 07	1034.2	1.666	0.012
FEB	588.0	642.5	42.3	0.1311E 08	0.2382E 07	1484.8	1.476	0.052
MAR	947.1	638.9	44.4	0.1303E 08	0.2637E 07	2165.4	1.251	0.097
APR	1370.4	493.6	48.6	0.1007E 08	0.2552E 07	2919.6	1.070	0.156
MAY	1737.8	316.2	54.9	0.6450E 07	0.2637E 07	3496.1	0.960	0.260
JUN	1841.5	154.7	60.6	0.3156E 07	0.2552E 07	3755.5	0.915	0.387
JUL	2142.4	46.2	66.2	0.9425E 06	0.2637E 07	3635.9	0.936	0.684
AUG	1774.7	50.1	65.4	0.1022E 07	0.2637E 07	3156.7	1.033	0.618
SEP	1328.3	140.6	61.0	0.2868E 07	0.2552E 07	2446.9	1.211	0.383
OCT	769.4	397.1	52.2	0.8101E 07	0.2637E 07	1700.3	1.433	0.127
NOV	410.4	605.6	44.8	0.1235E 08	0.2552E 07	1135.5	1.615	0.033
DEC	277.4	748.0	40.9	0.1526E 08	0.2637E 07	904.9	1.660	0.005
TOTAL		5017.0		0.1023E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.134

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	34.52
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0266
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0366
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1413
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	8.1301
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	33.7563
HEAT EXCHANGER LENGTH (FT)	87.36
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT).....	0.1047
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.552E 05
STORAGE SIDE REYNOLDS NUMBER	0.499E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0090
FLOW PARAMETER Z2(GCP/FRUL).............	9.5356
FLOW PARAMETER Z1(GCP/FRPUL)............	9.03

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.990E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.110E 06
COLLECTOR SIDE CONVECTION COEFF.........	2860.3540
STORAGE SIDE CONVECTION COEFFICIENT	5892.4609
COLLECTOR SIDE FLOW RATE (GPM)	2.0293
STORAGE SIDE FLOW RATE (GPM)	221.7651
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	2.2177
HEAT EXCHANGER EFFECTIVENESS.............	0.9473
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.178E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.133E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1337
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	-0.542E 02
HEX COEFFICIENT (BTU/HR F FT**2)........	401.24
TOTAL INSTALLATION COST ($)	2995.62
COLLECTOR FLOW FACTOR(FPP)..............	0.9466

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                         *              S O L O A D - 1                  *
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                         *   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN*
                         *   ---          -            -          -      *
                         *       DESIGN DATA OPTIONS/INPUTS SUMMARY      *
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                                  >>>>>DATA MATCH TO OUTPUT ID NO.  3213
                                                IMOD-1 LWK AUGUST 1979


LOCATION      SALEM      OREGON     COLLECTOR SOLARNETICS               STUDY APPROACH        ANALYSIS
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LOCATION INDEX.......         3     COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....      44.92       SLOPE:                            ------------------
MEAN TEMPERATURE....      51.75        PARAMETER,FRUL....    1.0380
INSOL(BTU/DAY FT**2)    1126.63        INTERCEPT:                       SYSTEM LIFE(YEARS)..    20.00
LOAD FACTOR,FCC.....    5017.00        PARAMETER,FRTA....    0.6910     DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...    12.98      INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS
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TYPE ENERGY BASE.........................           OIL    COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE       COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL      0.70   0.90($/GAL)  142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE      0.99   0.05($/KWH)    3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS      0.70   0.40($/THM)  100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                           STORAGE FLUID DENSITY(LB/FT**3).........         62.09
                                                           STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                                  STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                                  COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                           STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                           HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.00      ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00      ESTIMATED GROUND REFLECTANCE...........,          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........     10799.99      ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00      ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...         20.00      ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............         0.00      ESTIMATED HEX COST ($/FT**2) ...........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00      ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                           MAINTENANCE (% INSTALLED COST/YR).......          0.00
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SOLOAD-1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>>DATA MATCH TO INPUT ID NO. 3213
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.8462E 07	0.2637E 07	1034.2	1.626	0.028
FEB	588.0	642.5	42.3	0.6939E 07	0.2382E 07	1484.8	1.490	0.111
MAR	947.1	638.9	44.4	0.6900E 07	0.2637E 07	2169.4	1.255	0.196
APR	1370.4	493.6	48.6	0.5331E 07	0.2552E 07	2919.6	1.067	0.300
MAY	1737.8	316.2	54.9	0.3415E 07	0.2637E 07	3496.1	0.952	0.451
JUN	1841.6	154.7	60.6	0.1671E 07	0.2552E 07	3755.5	0.906	0.589
JUL	2142.4	46.2	66.2	0.4990E 06	0.2637E 07	3635.9	0.927	0.853
AUG	1774.7	50.1	65.4	0.5411E 06	0.2637E 07	3156.7	1.028	0.790
SEP	1328.3	140.6	61.0	0.1518E 07	0.2552E 07	2446.9	1.213	0.584
OCT	769.4	397.1	52.2	0.4289E 07	0.2637E 07	1700.3	1.445	0.243
NOV	410.4	605.6	44.8	0.6540E 07	0.2552E 07	1139.5	1.635	0.071
DEC	277.4	748.0	40.9	0.8078E 07	0.2637E 07	904.9	1.683	0.013
TOTAL		5017.0		0.5418E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.244

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	129.13
COLLECTOR TILT ANGLE (DEG) ....>>>	36.24
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0521
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0621
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1211
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.7651
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.0250
HEAT EXCHANGER LENGTH (FT)	70.10
///////////////CONSTRAINTS//////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0589
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.368E 05
STORAGE SIDE REYNOLDS NUMBER	0.150E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0378
FLOW PARAMETER Z2(UCP/FRUL).............	9.6424
FLOW PARAMETER Z1(UCP/FRPUL)............	9.13

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.129E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.342E 05
COLLECTOR SIDE CONVECTION COEFF.........	1055.0974
STORAGE SIDE CONVECTION COEFFICIENT	3543.8760
COLLECTOR SIDE FLOW RATE (GPM)	2.6498
STORAGE SIDE FLOW RATE (GPM)	68.5733
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.5310
HEAT EXCHANGER EFFECTIVENESS............	0.9330
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.208E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.852E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2444
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.117E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	311.98
TOTAL INSTALLATION COST ($)	3182.85
COLLECTOR FLOW FACTOR(FPP).............	0.9472

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                    S O L O A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

          DESIGN DATA OPTIONS/INPUTS SUMMARY

                    >>>>>DATA MATCH TO OUTPUT ID NO.  3222
                                   IMCD-1 LJK AUGUST 1979


LOCATION      SALEM     OREGON    COLLECTOR AMERICAN SUN                 STUDY APPROACH           ANALYSIS

LOCATION INDEX.......       3     COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....    44.92       SLOPE:
MEAN TEMPERATURE....    51.75       PARAMETER,FRUL....      1.0390
INSOL(BTU/DAY FT**2)  1126.63       INTERCEPT:                           SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....  5017.00       PARAMETER,FRTA....      0.6380       DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....    55.00     BASE COST,$/FT**2...        6.55       INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS

TYPE ENERGY BASE.........................       OIL          COLLECTOR FLUID MEAN TEMPERATURE........   176.00
INDEX TYPE EFFICIENCY    COST         HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......    60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).   1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)         COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)   0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE ........    104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........    62.09
                                                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...   1.0000
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).   0.3640
                                                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)    0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......   220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....    15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00         ESTIMATED GROUND REFLECTANCE...........,     0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99         ESTIMATED PUMPING POWER(KWH/AREAC)......   1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00         ESTIMATED CORRECTION FOR TAU ALPHA PRED.     0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..    10.00
ESTIMATED DHW USERS (PER)...............        6.00         ESTIMATED HEX COST ($/FT**2) ..........      5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00         ESTIMATED STORAGE TANK COST($/LB STORED)     0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......   0.0010
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S O L T A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>>DATA MATCH TO INPUT ID NO. 3222
OMDD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.1598E 08	0.2637E 07	1034.2	1.640	0.022
FEB	538.0	642.5	42.3	0.1311E 08	0.2382E 07	1484.8	1.500	0.106
MAR	947.1	638.9	44.4	0.1303E 08	0.2637E 07	2169.4	1.258	0.193
APR	1370.4	493.6	48.6	0.1007E 08	0.2552E 07	2919.6	1.063	0.304
MAY	1737.8	316.2	54.9	0.6450E 07	0.2637E 07	3496.1	0.946	0.479
JUN	1841.6	154.7	60.6	0.3156E 07	0.2552E 07	3755.5	0.899	0.663
JUL	2142.4	46.2	66.2	0.9425E 06	0.2637E 07	3635.9	0.920	0.969
AUG	1774.7	50.1	65.4	0.1022E 07	0.2637E 07	3156.7	1.023	0.915
SEP	1328.3	140.6	61.0	0.2868E 07	0.2552E 07	2446.9	1.214	0.668
OCT	769.4	397.1	52.2	0.8101E 07	0.2637E 07	1700.3	1.454	0.253
NOV	410.4	605.6	44.8	0.1235E 08	0.2552E 07	1139.5	1.650	0.066
DEC	277.4	748.0	40.9	0.1526E 08	0.2637E 07	904.9	1.699	0.007
TOTAL		5017.0		0.1023E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.235

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	237.92
COLLECTOR TILT ANGLE (DEG) ....>>>	37.53
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0704
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0781
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1436
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.8680
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.6433
HEAT EXCHANGER LENGTH (FT)	86.47
////////////////////CONSTRAINTS////////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0655
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0078
COLLECTOR SIDE REYNOLDS NUMBER..............	0.515E 05
STORAGE SIDE REYNOLDS NUMBER	0.191E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0464
FLOW PARAMETER Z2(GCF/FFUL)................	9.8745
FLOW PARAMETER Z1(GCP/F2PUL)...............	9.37

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.244E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.526E 05
COLLECTOR SIDE CONVECTION COEFF..........	1023.1746
STORAGE SIDE CONVECTION COEFFICIENT	3856.6736
COLLECTOR SIDE FLOW RATE (GPM)	5.0045
STORAGE SIDE FLOW RATE (GPM)	105.6521
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0210
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4441
HEAT EXCHANGER EFFECTIVENESS.............	0.9052
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.313E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.133E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2348
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.218E 04
HEX COEFFICIENT (BTU/HR F FT**2).........	309.83
TOTAL INSTALLATION COST ($)	4324.26
COLLECTOR FLOW FACTOR(FPP).................	0.9485

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                                   S O L O A D - 1
                      SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
                                  DESIGN DATA OPTIONS/INPUTS SUMMARY
                                              >>>>>DATA MATCH TO OUTPUT ID NO.  3223
                                                          IMCO-1 LWK AUGUST 1979

LOCATION     SALEM      OREGON     COLLECTOR AMERICAN SUN                    STUDY APPROACH           ANALYSIS
--------                           ----------                                ---------------

LOCATION INDEX......          3    COLLECTOR TEST RESULTS,                   ECONOMIC ESTIMATES
LATITUDE,DEGREES....      44.92      SLOPE:                                  ------------------
MEAN TEMPERATURE....      51.75      PARAMETER,FRUL....      1.0390
INSOL(BTU/DAY FT**2)    1126.63      INTERCEPT:                              SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....    5017.00      PARAMETER,FRTA....      0.6380          DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....      55.00    BASE COST,$/FT**2...        6.55          INFLATION RATE......     0.1100

ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
----------------------------                          -------------------

TYPE ENERGY BASE.............................  OIL    COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1   OIL    0.70  0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE    0.99  0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS    0.70  0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........      62.09
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                      COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..     0.09     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..  5000.00     ESTIMATED GROUND REFLECTANCE............       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........ 10799.99     ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...   140.00     ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...    20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............     6.00     ESTIMATED HEX COST ($/FT**2) ...........       5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.     1.00     ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>>DATA MATCH TO INPUT ID NO. 3223
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.8462E 07	0.2637E 07	1034.2	1.639	0.028
FEB	588.0	642.5	42.3	0.6939E 07	0.2382E 07	1484.8	1.499	0.128
MAR	947.1	638.9	44.4	0.6900E 07	0.2637E 07	2169.4	1.258	0.229
APR	1370.4	493.6	48.6	0.5331E 07	0.2552E 07	2919.6	1.064	0.349
MAY	1737.8	316.2	54.9	0.3415E 07	0.2637E 07	3496.1	0.947	0.517
JUN	1841.6	154.7	60.6	0.1671E 07	0.2552E 07	3755.5	0.899	0.661
JUL	2142.4	46.2	66.2	0.4990E 06	0.2637E 07	3635.9	0.921	0.916
AUG	1774.7	50.1	65.4	0.5411E 06	0.2637E 07	3156.7	1.024	0.859
SEP	1323.3	140.6	61.0	0.1518E 07	0.2552E 07	2446.9	1.214	0.660
OCT	769.4	397.1	52.2	0.4289E 07	0.2637E 07	1700.3	1.453	0.284
NOV	410.4	605.6	44.8	0.6546E 07	0.2552E 07	1139.5	1.649	0.079
DEC	277.4	748.0	40.9	0.8078E 07	0.2637E 07	904.9	1.658	0.009
TOTAL		5017.0		0.5413E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.275

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	176.82	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.177E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	37.45	STORAGE SIDE CAPACITY (BTU/HR F).......	0.325E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0572	COLLECTOR SIDE CONVECTION COEFF.........	1149.8711
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0622	STORAGE SIDE CONVECTION COEFFICIENT	3425.9775
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1208	COLLECTOR SIDE FLOW RATE (GPM)	3.6364
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1514	STORAGE SIDE FLOW RATE (GPM)	65.2807
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.2766	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
HEAT EXCHANGER LENGTH (FT)	57.70	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3692
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.8351
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0586	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.234E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.852E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.460E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2748
STORAGE SIDE REYNOLDS NUMBER	0.143E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.167E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0546	HEX COEFFICIENT (BTU/HR F FT**2)........	317.56
FLOW PARAMETER Z2(SCF/FPUL).............	9.6544	TOTAL INSTALLATION COST ($)	3194.66
FLOW PARAMETER Z1(CP/FPUL)..............	9.15	COLLECTOR FLOW FACTOR(FPP).............	0.9473

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                         S O L A D - 1
          SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
                 DESIGN DATA OPTIONS/INPUTS SUMMARY
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                      >>>>>DATA MATCH TO OUTPUT ID NO.  3232
                                   IMCD-1 LWK AUGUST 1979

LOCATION      SALEM      OREGON     COLLECTOR FEDERAL PRISON I. D        STUDY APPROACH           ANALYSIS
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LOCATION INDEX......           3    COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....       44.92      SLOPE:                             ------------------
MEAN TEMPERATURE....       51.75      PARAMETER,FRUL....     0.8830
INSOL(BTU/DAY FT**2)     1126.63      INTERCEPT:                         SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....     5017.00      PARAMETER,FRTA....     0.6270      DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00    BASE COST,$/FT**2...       9.40      INFLATION RATE......       0.1100

ENERGY COMPARATIVE ESTIMATES                                SELECTED PARAMETERS
----------------------------                                -------------------

TYPE ENERGY BASE..........................OIL               COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST       HEATING VALUE            COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL    0.70   0.90($/GAL)  142000.0(BTU/GAL)          COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2   ELE    0.99   0.05($/KWH)    3413.0(BTU/KWH)          COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS    0.70   0.40($/THM)  100000.0(BTU/THM)          STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                            STORAGE FLUID DENSITY(LB/FT**3).........        62.09
HEAT LOAD CHARACTERISTICS                                   STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
-------------------------                                   STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
                                                            COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                            STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                            HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.17         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00         ESTIMATED GROUND REFLECTANCE...........,         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   20397.09         ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00         ESTIMATED CORRECTION FOR TAU ALPHA PROD.         0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............       6.00         ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00         ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                            MAINTENANCE (% INSTALLED COST/YR).......       0.0010
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR SALEM OREGON

>>>>>DATA MATCH TO INPUT ID NO. 3232
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.1598E 08	0.2637E 07	1034.2	1.640	0.032
FEB	588.0	642.5	42.3	0.1311E 08	0.2382E 07	1484.8	1.500	0.110
MAR	947.1	638.9	44.4	0.1303E 08	0.2637E 07	2169.4	1.258	0.191
APR	1370.4	493.6	48.6	0.1007E 08	0.2552E 07	2919.6	1.063	0.295
MAY	1737.8	316.2	54.9	0.6450E 07	0.2637E 07	3496.1	0.946	0.465
JUN	1841.6	154.7	60.6	0.3156E 07	0.2552E 07	3755.5	0.859	0.650
JUL	2142.4	46.2	66.2	0.9425E 06	0.2637E 07	3635.9	0.920	0.979
AUG	1774.7	50.1	65.4	0.1022E 07	0.2637E 07	3156.7	1.023	0.920
SEP	1328.3	140.6	61.0	0.2368E 07	0.2552E 07	2446.9	1.214	0.657
OCT	769.4	397.1	52.2	0.8101E 07	0.2637E 07	1700.3	1.453	0.251
NOV	410.4	605.6	44.8	0.1235E 08	0.2552E 07	1139.5	1.649	0.074
DEC	277.4	748.0	40.9	0.1526E 08	0.2637E 07	904.9	1.699	0.018
TOTAL		5017.0		0.1023E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.236

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	218.36
COLLECTOR TILT ANGLE (DEG) ....>>>	37.51
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0593
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0697
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1321
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.9737
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.4650
HEAT EXCHANGER LENGTH (FT)	36.64
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0624
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0099
COLLECTOR SIDE REYNOLDS NUMBER..........	0.45[illegible]E 05
STORAGE SIDE REYNOLDS NUMBER	0.172E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0425
FLOW PARAMETER Z2(GCP/FRUL).............	9.4883
FLOW PARAMETER Z1(GCP/FRPUL)............	3.98

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.183E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.430E 05
COLLECTOR SIDE CONVECTION COEFF.........	1087.9956
STORAGE SIDE CONVECTION COEFFICIENT	3721.4675
COLLECTOR SIDE FLOW RATE (GPM)	3.7508
STORAGE SIDE FLOW RATE (GPM)	26.4347
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0172
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3958
HEAT EXCHANGER EFFECTIVENESS............	0.9347
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.315E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.133E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2361
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.198E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	315.41
TOTAL INSTALLATION COST ($)	4584.81
COLLECTOR FLOW FACTOR(FPP)..............	0.9463

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*                 S O L O A D - 1                   *
*                                                   *
*  SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN     *
*  ---          -            -        -             *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                    >>>>>DATA MATCH TO OUTPUT ID NO.  3233
                                 IMOD-1 LWK AUGUST 1979


LOCATION       SALEM     OREGON    COLLECTOR FEDERAL PRISON I. D        STUDY APPROACH          ANALYSIS
--------                           ---------                            --------------

LOCATION INDEX......         3     COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....     44.92        SLOPE:                            ------------------
MEAN TEMPERATURE....     51.75        PARAMETER,FRUL....      0.8830
INSOL(BTU/DAY FT**2)   1126.63        INTERCEPT:                        SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....   5017.00        PARAMETER,FRTA....      0.6270    DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....     55.00     BASE COST,$/FT**2...         9.40    INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
----------------------------                              -------------------

TYPE ENERGY BASE...........................         OIL   COLLECTOR FLUID MEAN TEMPERATURE.........    176.0
INDEX TYPE EFFICIENCY    COST          HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3)........     60.8
  1    OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).    1.000
  2    ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.387
  3    GAS     0.70    0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE .........    104.0
                                                          STORAGE FLUID DENSITY(LB/FT**3).........     62.0
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...    1.000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).    0.364
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HF F/BTU)     0.001
                                                          STORAGE SIDE FOULING FACTOR(HF F/BTU)       0.001
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F).......    220.0
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.99      ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....     15.
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00      ESTIMATED GROUND REFLECTANCE...........,      0.2
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99      ESTIMATED PUMPING POWER(KWH/AREAC)......    1.000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00      ESTIMATED CORRECTION FOR TAU ALPHA PRED.      0.9
ESTIMATED DAILY DHW USAGE (GAL/PER) ...        20.00      ESTIMATED INSTALL/LABOR COST ($/AREAC)..     10.0
ESTIMATED DHW USERS (PER)...............        6.00      ESTIMATED HEX COST ($/FT**2) ...........      5.0
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00      ESTIMATED STORAGE TANK COST($/LB STORED)      0.3
                                                          MAINTENANCE (% INSTALLED COST/YR).......    0.001
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*                                                   *
*                S O L A D - 1                      *
*                                                   *
*     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
*     ---          -            -          -        *
*        RESULTS OF ANALYSIS FOR SALEM     OREGON   *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * *
                    >>>>>DATA MATCH TO INPUT ID NO.  3233
                                  MOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	332.1	783.5	39.7	0.8462E 07	0.2637E 07	1034.2	1.635	0.041
FEB	586.0	642.5	42.3	0.6939E 07	0.2382E 07	1484.8	1.496	0.136
MAR	947.1	638.9	44.4	0.6900E 07	0.2637E 07	2169.4	1.257	0.233
APR	1370.4	493.6	48.6	0.5331E 07	0.2552E 07	2919.6	1.065	0.351
MAY	1737.8	316.2	54.9	0.3415E 07	0.2637E 07	3496.1	0.948	0.518
JUN	1841.6	154.7	60.6	0.1671E 07	0.2552E 07	3755.5	0.901	0.665
JUL	2142.4	46.2	66.2	0.4990E 06	0.2637E 07	3635.9	0.923	0.931
AUG	1774.7	50.1	65.4	0.5411E 06	0.2637E 07	3156.7	1.025	0.870
SEP	1328.3	140.6	61.0	0.1518E 07	0.2552E 07	2446.9	1.213	0.663
OCT	769.4	397.1	52.2	0.4289E 07	0.2637E 07	1700.3	1.451	0.290
NOV	410.4	605.6	44.8	0.6540E 07	0.2552E 07	1139.5	1.644	0.091
DEC	277.4	748.0	40.9	0.8078E 07	0.2637E 07	904.9	1.693	0.023
TOTAL		5017.0		0.5418E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.263

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	166.68
COLLECTOR TILT ANGLE (DEG) ....>>>	37.06
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0594
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0680
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1235
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.3133
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.2154
HEAT EXCHANGER LENGTH (FT)	69.64
///////////////////CONSTRAINTS///////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0555
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0086
COLLECTOR SIDE REYNOLDS NUMBER...........	0.350E 05
STORAGE SIDE REYNOLDS NUMBER	0.143E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0413
FLOW PARAMETER Z2(UCP/FRUL)..............	9.5292
FLOW PARAMETER Z1(UCP/FRPUL).............	9.02

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.140E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.340E 05
COLLECTOR SIDE CONVECTION COEFF..........	891.2476
STORAGE SIDE CONVECTION COEFFICIENT	3584.9177
COLLECTOR SIDE FLOW RATE (GPM)	2.8754
STORAGE SIDE FLOW RATE (GPM)	66.2253
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0173
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4053
HEAT EXCHANGER EFFECTIVENESS.............	0.9302
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.241E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.852E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2831
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.153E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	295.52
TOTAL INSTALLATION COST ($)	3502.55
COLLECTOR FLOW FACTOR(FPP)...............	0.9466

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*              S O L O A D - 1                  *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY     *
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               >>>>>DATA MATCH TO OUTPUT ID NO.  4111
                              IMOD-1 LWK AUGUST 1979


LOCATION        PORTLAND   MAINE     COLLECTOR SOLARNETICS                     STUDY APPROACH          ANALYSIS
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LOCATION INDEX......            4    COLLECTOR TEST RESULTS,                   ECONOMIC ESTIMATES
LATITUDE,DEGREES....        43.65       SLOPE:                                 ------------------
MEAN TEMPERATURE....        45.38       PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)      1050.57       INTERCEPT:                             SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,FDD.....      7410.39       PARAMETER,FRTA....       0.6910        DISCOUNT RATE ......       0.1150
MEAN GROUND TEMP....        55.00    BASE COST,$/FT**2...        12.98         INFLATION RATE......       0.1050


ENERGY COMPARATIVE ESTIMATES                            SELECTED PARAMETERS
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TYPE ENERGY BASE..........................         OIL  COLLECTOR FLUID MEAN TEMPERATURE........          176.00
INDEX TYPE EFFICIENCY   COST         HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......           60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).          1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)          0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........           104.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........           62.09
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...          1.0000
-------------------------                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).          0.3640
                                                        COLLECTOR SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)             0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......          220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.25    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....           15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00    ESTIMATED GROUND REFLECTANCE...........,            0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    30000.00    ESTIMATED PUMPING POWER(KWH/AREAC)......          1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.            0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..           10.00
ESTIMATED DHW USERS (PER)...............        3.00    ESTIMATED HEX COST ($/FT**2) ...........            5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00    ESTIMATED STORAGE TANK COST($/LB STORED)            0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......            0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TO INPUT ID NO. 4111
UMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.3983E 08	0.2637E 07	1100.1	1.754	0.015
FEB	681.6	1152.7	24.2	0.3458E 08	0.2382E 07	1548.6	1.509	0.028
MAR	969.6	1013.4	32.3	0.3040E 08	0.2637E 07	2222.9	1.239	0.046
APR	1304.0	664.7	42.8	0.1994E 08	0.2552E 07	2953.7	1.050	0.081
MAY	1567.0	379.9	52.9	0.1140E 08	0.2637E 07	3509.2	0.941	0.148
JUN	1712.0	118.5	62.7	0.3555E 07	0.2552E 07	3757.2	0.898	0.330
JUL	1659.0	22.1	68.0	0.6630E 06	0.2637E 07	3643.1	0.918	0.554
AUG	1461.0	42.0	66.6	0.1260E 07	0.2637E 07	3182.9	1.004	0.468
SEP	1158.0	202.8	59.0	0.6084E 07	0.2552E 07	2494.3	1.170	0.205
OCT	822.3	502.1	48.8	0.1506E 08	0.2637E 07	1761.6	1.432	0.086
NOV	459.2	785.4	38.8	0.2356E 08	0.2552E 07	1205.3	1.632	0.024
DEC	362.8	1199.0	26.3	0.3597E 08	0.2637E 07	970.6	1.795	0.010
TOTAL		7410.4		0.2223E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.068

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	35.71
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0341
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0441
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1344
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.9560
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	25.9774
HEAT EXCHANGER LENGTH (FT)	72.87
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0703
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER	0.431E 05
STORAGE SIDE REYNOLDS NUMBER	0.331E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0135
FLOW PARAMETER Z2(GCP/FRUL)............	9.5369
FLOW PARAMETER Z1(GCP/FRPUL)............	9.03

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.990E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.735E 05
COLLECTOR SIDE CONVECTION COEFF.........	1832.0872
STORAGE SIDE CONVECTION COEFFICIENT	4701.6367
COLLECTOR SIDE FLOW RATE (GPM)	2.0296
STORAGE SIDE FLOW RATE (GPM)	147.5214
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.4752
HEAT EXCHANGER EFFECTIVENESS............	0.9428
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.171E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.253E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.0675
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	-0.176E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	366.27
TOTAL INSTALLATION COST ($)	2998.57
COLLECTOR FLOW FACTOR(FFP)..............	0.9466

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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN      *
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                     >>>>>DATA MATCH TO OUTPUT ID NO.  4112
                                     IMOD-1 LWK AUGUST 1979


LOCATION      PORTLAND   MAINE      COLLECTOR SOLARNETICS                      STUDY APPROACH          ANALYSIS
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LOCATION INDEX......         4      COLLECTOR TEST RESULTS,                    ECONOMIC ESTIMATES
LATITUDE,DEGREES....     43.65        SLOPE:                                   ------------------
MEAN TEMPERATURE....     45.38         PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)   1050.57         INTERCEPT:                              SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....   7410.39         PARAMETER,FRTA....       0.6910         DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00      BASE COST,$/FT**2...        12.98          INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
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TYPE ENERGY BASE..........................        OIL     COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE       COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)       COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)       COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)       STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.17       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00       ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   20399.99       ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00       ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USE OF (GAL/PER) ...      20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............       0.00       ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00       ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......        0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TO INPUT ID NO. 4112
OLOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.2709E 08	0.2637E 07	1100.1	1.752	0.022
FEB	681.6	1152.7	24.2	0.2352E 08	0.2382E 07	1548.6	1.508	0.040
MAR	969.6	1013.4	32.3	0.2067E 08	0.2637E 07	2222.9	1.239	0.065
APR	1304.0	664.7	42.8	0.1355E 08	0.2552E 07	2953.7	1.050	0.111
MAY	1567.0	379.9	52.9	0.7750E 07	0.2637E 07	3509.2	0.942	0.196
JUN	1712.0	118.5	62.7	0.2417E 07	0.2552E 07	3757.2	0.899	0.392
JUL	1659.0	22.1	68.0	0.4508E 06	0.2637E 07	3643.1	0.918	0.581
AUG	1461.0	42.0	66.6	0.8568E 06	0.2637E 07	3182.9	1.005	0.509
SEP	1158.0	202.8	59.0	0.4137E 07	0.2552E 07	2494.3	1.170	0.258
OCT	822.3	502.1	48.8	0.1024E 08	0.2637E 07	1761.6	1.431	0.117
NOV	459.2	785.4	38.8	0.1602E 08	0.2552E 07	1205.3	1.631	0.034
DEC	362.8	1199.0	26.3	0.2446E 08	0.2637E 07	970.6	1.793	0.015
TOTAL		7410.4		0.1512E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.092

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	36.00
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0453
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0553
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1212
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.7954
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.9064
HEAT EXCHANGER LENGTH (FT)	59.78
///////////////CONSTRAINTS//////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0659
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.323E 05
STORAGE SIDE REYNOLDS NUMBER	0.176E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0256
FLOW PARAMETER Z2(CCP/FRUL)............	9.5093
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.00

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.987E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.386E 05
COLLECTOR SIDE CONVECTION COEFF.........	1094.6016
STORAGE SIDE CONVECTION COEFFICIENT	3664.0430
COLLECTOR SIDE FLOW RATE (GPM)	2.0237
STORAGE SIDE FLOW RATE (GPM)	77.5582
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.7756
HEAT EXCHANGER EFFECTIVENESS............	0.9318
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.168E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.182E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.0921
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	-0.233E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	316.69
TOTAL INSTALLATION COST ($)	3002.77
COLLECTOR FLOW FACTOR(FPP).............	0.9464

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*         DESIGN DATA OPTIONS/INPUTS SUMMARY          *
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                 >>>>>DATA MATCH TO OUTPUT ID NO.  4113
                                 IMOD-1 LWK AUGUST 1979


LOCATION        PORTLAND   MAINE     COLLECTOR SOLARNETICS                STUDY APPROACH         ANALYSIS
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LOCATION INDEX......           4     COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....       43.65       SLOPE:                             ------------------
MEAN TEMPERATURE....       45.38       PARAMETER,FRUL....     1.0380
INSOL(BTU/DAY FT**2)     1050.57       INTERCEPT:                         SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,FDC.....     7410.39       PARAMETER,FRTA....     0.6910      DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....       55.00     BASE COST,$/FT**2...    12.98        INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                        SELECTED PARAMETERS
----------------------------                        -------------------

TYPE ENERGY BASE.........................     OIL   COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY    COST        HEATING VALUE  COLLECTOR FLUID DENSITY(LB/FT**3).......       60.31
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL) COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH) COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM) STORAGE FLUID MEAN TEMPERATURE .........      104.00
                                                    STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                    STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                           STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                           COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                    STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                    HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09  ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00  ESTIMATED GROUND REFLECTANCE............        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99  ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00  ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00  ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............      0.00  ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00  ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                    MAINTENANCE (% INSTALLED COST/YR).......        0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

\>>>>>DATA MATCH TO INPUT ID NO. 4113
DMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.1434E 08	0.2637E 07	1100.1	1.769	0.039
FEB	681.6	1152.7	24.2	0.1245E 08	0.2382E 07	1548.6	1.518	0.069
MAR	969.6	1013.4	32.3	0.1094E 08	0.2637E 07	2222.9	1.241	0.109
APR	1304.0	664.7	42.8	0.7179E 07	0.2552E 07	2953.7	1.046	0.178
MAY	1567.0	379.9	52.9	0.4103E 07	0.2637E 07	3509.2	0.935	0.287
JUN	1712.0	118.5	62.7	0.1280E 07	0.2552E 07	3757.2	0.891	0.478
JUL	1659.0	22.1	68.0	0.2387E 06	0.2637E 07	3643.1	0.911	0.606
AUG	1461.0	42.0	66.6	0.4536E 06	0.2637E 07	3182.9	1.000	0.554
SEP	1158.0	202.8	59.0	0.2190E 07	0.2552E 07	2494.3	1.170	0.348
OCT	822.3	502.1	48.8	0.5423E 07	0.2637E 07	1761.6	1.439	0.182
NOV	459.2	785.4	38.8	0.8462E 07	0.2552E 07	1205.3	1.645	0.057
DEC	362.8	1199.0	26.3	0.1295E 08	0.2637E 07	970.6	1.811	0.026
TOTAL		7410.4		0.8003E 08	0.3105E 08			

\>>>WEIGHTED AVERAGE 0.146

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.989E 03
COLLECTOR TILT ANGLE (DEG) ....>>>	37.85	STORAGE SIDE CAPACITY (BTU/HR F).......	0.571E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0414	COLLECTOR SIDE CONVECTION COEFF.........	1292.2117
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0514	STORAGE SIDE CONVECTION COEFFICIENT	4139.7383
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1312	COLLECTOR SIDE FLOW RATE (GPM)	2.0281
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3623	STORAGE SIDE FLOW RATE (GPM)	114.7034
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	22.3427	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
HEAT EXCHANGER LENGTH (FT)	61.63	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.1470
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9313
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0798	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.163E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.111E 09
COLLECTOR SIDE REYNOLDS NUMBER...........	0.355E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1465
STORAGE SIDE REYNOLDS NUMBER	0.252E 06	OBJECTIVE : NPV OF SOLAR INVESTMENT ..>>>	-0.316E 03
CAPACITY RATIO (CMIN/CMAX)..............	0.0173	HEX COEFFICIENT (BTU/HR F FT**2)........	334.59
FLOW PARAMETER Z2(GCP/FRUL).............	9.5297	TOTAL INSTALLATION COST ($)	2999.80
FLOW PARAMETER Z1(GCP/FRPUL)............	9.02	COLLECTOR FLOW FACTOR(FPP).............	0.9466

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*                   S O L O A D - 1                              *
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*     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN               *
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*          DESIGN DATA OPTIONS/INPUTS SUMMARY                    *
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              >>>>>DATA MATCH TO OUTPUT ID NO.  4222
                               IMCD-1 LWK AUGUST 1979


LOCATION        PORTLAND   MAINE     COLLECTOR AMERICAN SUN              STUDY APPROACH          ANALYSIS

LOCATION INDEX......         4       COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....     43.65         SLOPE:
MEAN TEMPERATURE....     45.38          PARAMETER,FRUL....     1.0390
INSOL(BTU/DAY FT**2)   1050.57          INTERCEPT:                       SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....   7410.39          PARAMETER,FRTA....     0.6380    DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....     55.00       BASE COST,$/FT**2...        6.55    INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                             SELECTED PARAMETERS

TYPE ENERGY BASE...........................         OIL  COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE .........      104.00
                                                         STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                         STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                                STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                         COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                         STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00     ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99     ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00     ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............        3.00     ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00     ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                         MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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*                                                   *
*                 S O L - I A D - 1                 *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---          -            -          -          *
*      RESULTS OF ANALYSIS FOR PORTLAND   MAINE     *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                 >>>>>DATA MATCH TO INPUT ID NO.  4222
                                  MOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.2709E 08	0.2637E 07	1100.1	1.814	0.053
FEB	631.6	1152.7	24.2	0.2352E 08	0.2382E 07	1548.6	1.543	0.095
MAR	969.6	1013.4	32.3	0.2067E 08	0.2637E 07	2222.9	1.243	0.151
APR	1304.0	664.7	42.8	0.1356E 08	0.2552E 07	2953.7	1.034	0.249
MAY	1567.0	379.9	52.9	0.7750E 07	0.2637E 07	3509.2	0.916	0.413
JUN	1712.0	118.5	62.7	0.2417E 07	0.2552E 07	3757.2	0.869	0.715
JUL	1659.0	22.1	68.0	0.4508E 06	0.2637E 07	3643.1	0.890	0.891
AUG	1461.0	42.0	66.6	0.3558E 06	0.2637E 07	3182.9	0.985	0.839
SEP	1158.0	202.8	59.0	0.4137E 07	0.2552E 07	2494.3	1.167	0.531
OCT	822.3	502.1	48.8	0.1024E 08	0.2637E 07	1761.6	1.457	0.269
NOV	459.2	785.4	38.8	0.1602E 08	0.2552E 07	1205.3	1.680	0.081
DEC	362.3	1199.0	26.3	0.2446E 08	0.2637E 07	970.6	1.860	0.035
TOTAL		7410.4		0.1512E 09	0.3105E 08			
							>>>WEIGHTED AVERAGE	0.190

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	280.31
COLLECTOR TILT ANGLE (DEG) ....>>>	41.4
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0710
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0760
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1327
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2148
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.8401
HEAT EXCHANGER LENGTH (FT)	69.38
///////////////CONSTRAINTS//////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0567
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.582E 05
STORAGE SIDE REYNOLDS NUMBER	0.151E 05
CAPACITY RATI (CMIN/MAX)................	0.0712
FLOW PARAMETER Z2(CCP/FRUL).............	9.5702
FLOW PARAMETER Z1(CCP/FRPUL)............	9.06

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.279E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.391E 05
COLLECTOR SIDE CONVECTION COEFF.........	1118.9341
STORAGE SIDE CONVECTION COEFFICIENT	3655.0542
COLLECTOR SIDE FLOW RATE (GPM)	5.7146
STORAGE SIDE FLOW RATE (GPM)	78.5578
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0204
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2802
HEAT EXCHANGER EFFECTIVENESS............	0.8158
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.346E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.182E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1897
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.209E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	316.43
TOTAL INSTALLATION COST ($)	5059.69
COLLECTOR FLOW FACTOR(FPP)..............	0.9468

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                    S C L O A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
     ---                       -        -     -
          DESIGN DATA OPTIONS/INPUTS SUMMARY

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                 >>>>>DATA MATCH TO OUTPUT ID NO.  4223
                               IMOD-1 LWK AUGUST 1979


LOCATION       PORTLAND  MAINE    COLLECTOR AMERICAN SUN              STUDY APPROACH         ANALYSIS
--------                          ---------                           --------------

LOCATION INDEX......        4     COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....    43.65       SLOPE:                            ------------------
MEAN TEMPERATURE....    45.38       PARAMETER,FRUL....    1.0390
INSOL(BTU/DAY FT**2)  1050.57       INTERCEPT:                        SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....  7410.39       PARAMETER,FRTA....    0.6380      DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....    55.00     BASE COST,$/FT**2...      6.55      INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
----------------------------                          -------------------

TYPE ENERGY BASE...........................OIL        COLLECTOR FLUID MEAN TEMPERATURE........    176.00
INDEX TYPE EFFICIENCY   COST       HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......     60.81
  1   OIL    0.70   0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).    1.0000
  2   ELE    0.99   0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)   0.3870
  3   GAS    0.70   0.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........    104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........     62.09
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...    1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).    0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)     0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......    220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....     15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00    ESTIMATED GROUND REFLECTANCE...........,      0.20
LOAD CONDUCTANCE (BTU/DEG F DAY).......   10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......    1.0000
DOMESTIC HOT WATER (DHW) DESIGN TEMP. ...   140.00    ESTIMATED CORRECTION FOR TAU ALPHA PROD.      0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..     10.00
ESTIMATED DHW USERS (PER)...............      6.00    ESTIMATED HEX COST ($/FT**2) ...........      5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00    ESTIMATED STORAGE TANK COST($/LB STORED)      0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......    0.0010
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S O L J A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TO INPUT ID NO. 4223
UMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.1434E 08	0.2637E 07	1100.1	1.794	0.063
FEB	681.6	1152.7	24.2	0.1245E 08	0.2382E 07	1548.6	1.532	0.114
MAR	969.6	1013.4	32.3	0.1094E 08	0.2637E 07	2222.9	1.243	0.178
APR	1304.0	664.7	42.8	0.7179E 07	0.2552E 07	2953.7	1.040	0.286
MAY	1567.0	379.5	52.9	0.4103E 07	0.2637E 07	3509.2	0.925	0.444
JUN	1712.0	118.5	62.7	0.1280E 07	0.2552E 07	3757.2	0.879	0.685
JUL	1659.0	22.1	68.0	0.2387E 06	0.2637E 07	3643.1	0.900	0.812
AUG	1461.0	42.0	66.6	0.4536E 06	0.2637E 07	3182.9	0.992	0.764
SEP	1158.0	202.8	59.0	0.2190E 07	0.2552E 07	2494.3	1.169	0.528
OCT	822.3	502.1	48.8	0.5423E 07	0.2637E 07	1761.6	1.449	0.295
NOV	459.2	785.4	38.8	0.8482E 07	0.2552E 07	1205.3	1.665	0.093
DEC	362.8	1199.0	26.3	0.1295E 08	0.2637E 07	970.6	1.839	0.041
TOTAL		7410.4		0.8003E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.223

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	199.88
COLLECTOR TILT ANGLE (DEG) ....>>>	39.82
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0584
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0634
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1153
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3789
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	15.7176
HEAT EXCHANGE LENGTH (FT)	44.65
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0519
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.503E 05
STORAGE SIDE REYNOLDS NUMBER	0.115E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0774
FLOW PARAMETER Z2(GPP/FRUL).............	9.5313
FLOW PARAMETER Z1(GPP/FPUL).............	9.02

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.198E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.256E 05
COLLECTOR SIDE CONVECTION COEFF.........	1210.9487
STORAGE SIDE CONVECTION COEFFICIENT	3218.1931
COLLECTOR SIDE FLOW RATE (GPM)	4.0582
STORAGE SIDE FLOW RATE (GPM)	51.3571
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2569
HEAT EXCHANGER EFFECTIVENESS............	0.7218
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.248E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.111E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2235
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.155E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	320.21
TOTAL INSTALLATION COST ($)	3593.59
COLLECTOR FLOW FACTOR(FPP)..............	0.9466

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                    S O L O A D - 1

      SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
                    
            DESIGN DATA OPTIONS/INPUTS SUMMARY

                 >>>>>DATA MATCH TO OUTPUT ID NO.  4232
                                  IMCD-1 LWK AUGUST 1979


LOCATION       PORTLAND   MAINE     COLLECTOR FEDERAL PRISON I. D        STUDY APPROACH       ANALYSIS
--------                            ---------                            --------------

LOCATION INDEX......          4     COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      43.65       SLOPE:                             ------------------
MEAN TEMPERATURE....      45.38       PARAMETER,FRUL....      0.8830
INSOL(BTU/DAY FT**2)    1050.57       INTERCEPT:                         SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....    7410.39       PARAMETER,FRTA....      0.6270     DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...        9.40     INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
----------------------------                          -------------------

TYPE ENERGY BASE.........................      OIL    COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY    COST       HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL    0.70    0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2   ELE    0.99    0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS    0.70    0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3)........        62.09
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
-------------------------                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
                                                      COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.17    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00    ESTIMATED GROUND REFLECTANCE...........         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  20399.99    ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...      20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............      6.00    ESTIMATED HEX COST ($/FT**2) ...........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00    ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......       0.0010
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*                 S O L O A D - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---          -           -            -         *
*     RESULTS OF ANALYSIS FOR PORTLAND    MAINE     *
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                    >>>>>DATA MATCH TO INPUT ID NO.  4232
                                OMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.2709E 08	0.2637E 07	1100.1	1.805	0.059
FEB	681.6	1152.7	24.2	0.2352E 08	0.2382E 07	1548.6	1.538	0.099
MAR	969.6	1013.4	32.3	0.2067E 08	0.2637E 07	2222.9	1.243	0.152
APR	1304.0	664.7	42.8	0.1356E 08	0.2552E 07	2953.7	1.037	0.249
MAY	1567.0	379.9	52.9	0.7750E 07	0.2637E 07	3509.2	0.920	0.413
JUN	1712.0	118.5	62.7	0.2417E 07	0.2552E 07	3757.2	0.874	0.723
JUL	1659.0	22.1	68.0	0.4508E 06	0.2637E 07	3643.1	0.895	0.917
AUG	1461.0	42.0	66.6	0.8568E 06	0.2637E 07	3182.9	0.988	0.858
SEP	1158.0	202.8	59.0	0.4137E 07	0.2552E 07	2494.3	1.166	0.533
OCT	822.3	502.1	48.8	0.1024E 08	0.2637E 07	1761.6	1.454	0.270
NOV	459.2	785.4	38.8	0.1602E 08	0.2552E 07	1205.3	1.673	0.089
DEC	362.8	1199.0	26.3	0.2446E 08	0.2637E 07	970.6	1.851	0.043
TOTAL		7410.4		0.1512E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.195

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     DESIGN VARIABLES/CONSTRAINTS                                  OTHER PARAMETERS
     ----------------------------                                  ----------------
COLLECTOR AREA   (FT**2) ...............>>>      260.18   COLLECTOR SIDE CAPACITY (BTU/HR  F)..... 0.219E 04
COLLECTOR TILT ANGLE   (DEG) ..........>>>        40.75   STORAGE SIDE CAPACITY (BTU/HR  F)....... 0.498E 05
COLLECTOR SIDE TUBE INNER DIA. (FT) ....         0.0653   COLLECTOR SIDE CONVECTION COEFF......... 1071.7600
COLLECTOR SIDE TUBE OUTER DIA. (FT) ....         0.0729   STORAGE SIDE CONVECTION COEFFICIENT .... 3853.5100
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..         0.1384   COLLECTOR SIDE FLOW RATE  (GPM) ........    4.4916
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..         2.9336   STORAGE SIDE FLOW RATE  (GPM) ..........  100.0824
STORAGE SIDE FLUID VELOCITY  (FT/SEC) ..        20.5306   NORMALIZED COLLECTOR FLOW (GPM/AREAC)...    0.0173
HEAT EXCHANGER LENGTH (FT) .............          94.61   NORMALIZED STORAGE FLOW  (GPM/AREAC) ...    0.3847
////////////////CONSTRAINTS///////////////                HEAT EXCHANGER EFFECTIVENESS............    0.9332
HEX ANNULAR DIAMETER DIFFERENCE (FT)....         0.0655   SOLAR ENERGY DELIVERED (BTU/YEAR)....... 0.354E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).         0.0075   TOTAL ENERGY DEMAND  (BTU/YEAR) ........ 0.182E 09
COLLECTOR SIDE REYNOLDS NUMBER..........      0.497E 05   ANNUAL AVERAGE SOLAR LOAD FRACTION .....    0.1945
STORAGE SIDE REYNOLDS NUMBER ...........      0.190E 06   OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>> 0.190E 04
CAPACITY RATIO (CMIN/CMAX)..............         0.0440   HEX COEFFICIENT (BTU/HR F FT**2)........    314.28
FLOW PARAMETER Z2(GCP/FRUL).............         9.5361   TOTAL INSTALLATION COST ($) ............   5463.02
FLOW PARAMETER Z1(GCP/FRPUL)............           9.03   COLLECTOR FLOW FACTOR(FPP)..............    0.9466
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*                S O L O A D - 1                    *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---          -            -        -            *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                   >>>>>DATA MATCH TO OUTPUT ID NO.   4233
                                   IMCD-1 LWK AUGUST 1979
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LOCATION        PORTLAND    MAINE
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LOCATION INDEX......                4
LATITUDE,DEGREES....            43.65
MEAN TEMPERATURE....            45.38
INSOL(BTU/DAY FT**2)          1050.57
LOAD FACTOR,FDD.....          7410.39
MEAN GROUND TEMP....            55.00
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COLLECTOR FEDERAL PRISON I. D
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COLLECTOR TEST RESULTS,
   SLOPE:
   PARAMETER,FRUL....        0.8830
   INTERCEPT:
   PARAMETER,FRTA....        0.6270
BASE COST,$/FT**2...           9.40
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STUDY APPROACH                      ANALYSIS
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ECONOMIC ESTIMATES
------------------
SYSTEM LIFE(YEARS)..           20.00
DISCOUNT RATE ......          0.0900
INFLATION RATE......          0.1100
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ENERGY COMPARATIVE ESTIMATES
----------------------------
TYPE ENERGY BASE.........................                 OIL
INDEX TYPE EFFICIENCY    COST           HEATING VALUE
  1    OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)
  3    GAS     0.70   0.40($/THM)  100000.0(BTU/THM)
```

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HEAT LOAD CHARACTERISTICS
-------------------------
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.09
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........     10799.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00
ESTIMATED DHW USERS (PER)...............         6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00
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SELECTED PARAMETERS
-------------------
COLLECTOR FLUID MEAN TEMPERATURE........           176.0
COLLECTOR FLUID DENSITY(LB/FT**3).......            60.8
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).           1.000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)          0.38
STORAGE FLUID MEAN TEMPERATURE ........            104.0
STORAGE FLUID DENSITY(LB/FT**3).........            62.
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...           1.00
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).           0.36
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)            0.001
STORAGE SIDE FOULING FACTOR(HR F/BTU)              0.001
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......           220.
ESTIMATED OPTIMUM STORAGE(LB/AREFAC) ....           15.
ESTIMATED GROUND REFLECTANCE............,           0.
ESTIMATED PUMPING POWER(KWH/AREFAC)......          1.000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.            0.
ESTIMATED INSTALL/LABOR COST ($/AREFAC)..          10.
ESTIMATED HEX COST ($/FT**2) ..........             5.
ESTIMATED STORAGE TANK COST($/LB STORED)            0.
MAINTENANCE (% INSTALLED COST/YR).......          0.001
```

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR PORTLAND MAINE

>>>>>DATA MATCH TO INPUT ID NO. 4233
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	450.3	1327.8	22.2	0.1434E 08	0.2637E 07	1100.1	1.797	0.076
FEB	681.6	1152.7	24.2	0.1245E 08	0.2382E 07	1548.6	1.534	0.126
MAR	969.6	1013.4	32.3	0.1094E 08	0.2637E 07	2222.9	1.243	0.192
APR	1304.0	664.7	42.8	0.7179E 07	0.2552E 07	2953.7	1.039	0.302
MAY	1567.0	379.9	52.9	0.4103E 07	0.2637E 07	3509.2	0.924	0.465
JUN	1712.0	118.5	62.7	0.1240E 07	0.2552E 07	3757.2	0.878	0.714
JUL	1659.0	22.1	68.0	0.2337E 06	0.2637E 07	3643.1	0.899	0.847
AUG	1461.0	42.0	66.6	0.4536E 06	0.2637E 07	3182.9	0.991	0.798
SEP	1158.0	202.8	59.0	0.2190E 07	0.2552E 07	2494.3	1.169	0.555
OCT	822.3	502.1	48.8	0.5423E 07	0.2637E 07	1761.6	1.450	0.314
NOV	459.2	785.4	38.8	0.8482E 07	0.2552E 07	1205.3	1.667	0.109
DEC	362.8	1199.0	26.3	0.1295E 08	0.2637E 07	970.6	1.841	0.054
TOTAL		7410.4		0.8003E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.240

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	194.39
COLLECTOR TILT ANGLE (DEG) ....>>>	40.04
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0557
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0629
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1247
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.0824
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.1571
HEAT EXCHANGER LENGTH (FT)	80.01
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0617
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0073
COLLECTOR SIDE REYNOLDS NUMBER	0.438E 05
STORAGE SIDE REYNOLDS NUMBER	0.158E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0445
FLOW PARAMETER Z2(CCP/FRUL).............	9.5527
FLOW PARAMETER Z1(CCP/FRPUL)............	9.04

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.164E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.369E 05
COLLECTOR SIDE CONVECTION COEFF.........	1135.7930
STORAGE SIDE CONVECTION COEFFICIENT	3541.9067
COLLECTOR SIDE FLOW RATE (GPM)	3.3703
STORAGE SIDE FLOW RATE (GPM)	74.1427
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0173
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3904
HEAT EXCHANGER EFFECTIVENESS............	0.9278
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.267E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.111E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2404
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.146E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	317.89
TOTAL INSTALLATION COST ($)	4039.32
COLLECTOR FLOW FACTOR(FPP)..............	0.9467

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*                 S O L O A C - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
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              >>>>>DATA MATCH TO OUTPUT ID NO.  9111
                              IMOD-1 LWK AUGUST 1979


LOCATION      OAKLAND  CALIF.    COLLECTOR SOLARNETICS              STUDY APPROACH          ANALYSIS
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LOCATION INDEX......         9   COLLECTOR TEST RESULTS,            ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.73     SLOPE:                           ------------------
MEAN TEMPERATURE....     56.59     PARAMETER,FRUL....    1.0380
INSOL(BTU/DAY FT**2)   1535.21     INTERCEPT:                       SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....   3145.40     PARAMETER,FRTA....    0.6910     DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00   BASE COST,$/FT**2...    12.98      INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                         SELECTED PARAMETERS
----------------------------                         -------------------

TYPE ENERGY BASE.........................     OIL    COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1   OIL    0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE    0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS    0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                     STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                     STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                            STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                            COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                     STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                     HEX TUBE CONDUCTIVITY(BTU/HR FT F).....      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.25   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00   ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  30000.00   ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............      6.00   ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00   ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                     MAINTENANCE (% INSTALLED COST/YR).......        0.01
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*               S O L O A D - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
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*     RESULTS OF ANALYSIS FOR OAKLAND   CALIF.    *
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                    >>>>>DATA MATCH TO INPUT ID NO.  9111
                                OMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.1555E 08	0.2637E 07	1407.4	1.639	0.160
FEB	1017.4	376.5	51.7	0.1130E 08	0.2382E 07	1838.5	1.448	0.263
MAR	1456.3	370.3	53.1	0.1111E 08	0.2637E 07	2458.1	1.222	0.360
APR	1922.1	291.5	55.3	0.8745E 07	0.2552E 07	3095.3	1.034	0.467
MAY	2211.3	222.0	58.0	0.6660E 07	0.2637E 07	3553.7	0.915	0.570
JUN	2350.0	138.2	61.0	0.4146E 07	0.2552E 07	3750.2	0.867	0.708
JUL	2322.5	110.2	61.8	0.3306E 07	0.2637E 07	3660.4	0.889	0.787
AUG	2052.6	91.2	62.4	0.2736E 07	0.2637E 07	3287.3	0.983	0.819
SEP	1701.2	75.6	63.4	0.2268E 07	0.2552E 07	2698.9	1.153	0.835
OCT	1212.0	151.3	60.4	0.4539E 07	0.2637E 07	2037.5	1.383	0.572
NOV	822.2	307.4	54.6	0.9222E 07	0.2552E 07	1510.1	1.613	0.281
DEC	647.0	493.0	49.1	0.1479E 08	0.2637E 07	1279.6	1.725	0.158
TOTAL		3145.4		0.9436E 08	0.3105E 08			
						>>>WEIGHTED	AVERAGE	0.399

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	202.53
COLLECTOR TILT ANGLE (DEG) ....>>>	35.27
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0634
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0698
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1347
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.9750
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.0411
HEAT EXCHANGER LENGTH (FT)	88.08
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0648
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0065
COLLECTOR SIDE REYNOLDS NUMBER	0.481E 05
STORAGE SIDE REYNOLDS NUMBER	0.183E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0440
FLOW PARAMETER Z2(CCP/FRPUL)............	9.7676
FLOW PARAMETER Z1(GCP/FRPUL)............	9.26

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.205E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.466E 05
COLLECTOR SIDE CONVECTION COEFF.........	1075.9285
STORAGE SIDE CONVECTION COEFFICIENT	3792.2302
COLLECTOR SIDE FLOW RATE (GPM)	4.2100
STORAGE SIDE FLOW RATE (GPM)	93.6330
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4623
HEAT EXCHANGER EFFECTIVENESS............	0.9262
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.500E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.125E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3988
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.217E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	314.20
TOTAL INSTALLATION COST ($)	6083.24
COLLECTOR FLOW FACTOR(FPP)...............	0.9479

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*                  S O L O A D - 1                     *
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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN      *
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*           DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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              >>>>>DATA MATCH TO OUTPUT ID NO.   9112
                                IMOD-1 LWK AUGUST 1979


LOCATION       OAKLAND   CALIF.   COLLECTOR SOLARMETICS                 STUDY APPROACH        ANALYSIS
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LOCATION INDEX......         9    COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.73      SLOPE:                              ------------------
MEAN TEMPERATURE....     56.59      PARAMETER,FRUL....     1.0380
INSUL(BTU/DAY FT**2)   1535.21      INTERCEPT:                          SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HOD.....   3145.40      PARAMETER,FRTA....     0.6910       DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00    BASE COST,$/FT**2...      12.98       INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
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TYPE ENERGY BASE...........................         OIL   COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY   COST         HEATING VALUE        COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3    GAS     0.70    0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17      ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00      ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99      ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00      ESTIMATED CORRECTION FOR TAU ALPHA PROD.       0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...        20.00      ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............       6.00      ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00      ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......       0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>>DATA MATCH TO INPUT ID NO. 9112
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.1057E 08	0.2637E 07	1407.4	1.641	0.171
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.449	0.277
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.223	0.376
APR	1922.1	291.5	55.3	0.5947E 07	0.2552E 07	3095.3	1.033	0.481
MAY	2211.3	222.0	58.0	0.4529E 07	0.2637E 07	3553.7	0.915	0.575
JUN	2350.0	138.2	61.0	0.2819E 07	0.2552E 07	3750.2	0.866	0.696
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.888	0.764
AUG	2052.6	91.2	62.4	0.1860E 07	0.2637E 07	3287.3	0.982	0.788
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.153	0.798
OCT	1212.0	151.3	60.4	0.3087E 07	0.2637E 07	2037.5	1.384	0.564
NOV	822.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.614	0.292
DEC	647.0	495.0	49.1	0.1006E 08	0.2637E 07	1279.6	1.727	0.168
TOTAL		3145.4		0.6417E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.413

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	158.46	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.158E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	35.39	STORAGE SIDE CAPACITY (BTU/HR F).......	0.346E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0614	COLLECTOR SIDE CONVECTION COEFF.........	922.3081
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0697	STORAGE SIDE CONVECTION COEFFICIENT	3654.8933
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1242	COLLECTOR SIDE FLOW RATE (GPM)	3.2395
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.4350	STORAGE SIDE FLOW RATE (GPM)	69.4442
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.6264	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0204
HEAT EXCHANGER LENGTH (FT)	70.69	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4382
//////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.9186
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0545	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.393E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0032	TOTAL ENERGY DEMAND (BTU/YEAR)	0.552E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.382E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4129
STORAGE SIDE REYNOLDS NUMBER	0.144E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.173E 04
CAPACITY RATIO (CMIN/CMAX).............	0.0457	HEX COEFFICIENT (BTU/HR F FT**2)........	299.13
FLOW PARAMETER Z2(UCP/FRUL)............	9.6064	TOTAL INSTALLATION COST ($)	4759.10
FLOW PARAMETER Z1(GCP/FRPUL)............	9.10	COLLECTOR FLOW FACTOR(FPP)..............	0.9470

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*                 S O L D A D - 1                 *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN   *
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*       DESIGN DATA OPTIONS/INPUTS SUMMARY        *
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                 >>>>>DATA MATCH TO OUTPUT ID NO.  9113
                                IMOD-1 LWK AUGUST 1979


LOCATION      OAKLAND   CALIF.     COLLECTOR SOLARNETICS                    STUDY APPROACH          ANALYSIS
--------                           ---------                                --------------

LOCATION INDEX......          9    COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.73      SLOPE:                                 ------------------
MEAN TEMPERATURE....      56.59      PARAMETER,FRUL....         1.0380
INSOL(BTU/DAY FT**2)    1535.21      INTERCEPT:                             SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,FDD.....    3145.40      PARAMETER,FRTA....         0.6910      DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....      55.00    BASE COST,$/FT**2...        12.98        INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS
----------------------------                                 -------------------

TYPE ENERGY BASE........................            OIL      COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)         COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........       62.09
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.09       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00       ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........      10799.99       ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00       ESTIMATED CORRECTION FOR TAU ALPHA FRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...         20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............          6.00       ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.          1.00       ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......        0.01
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*                                                   *
*                 S O L J A D - 1                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*   ---    -      -           -         -           *
*     RESULTS OF ANALYSIS FOR OAKLAND   CALIF.      *
*                                                   *
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                  >>>>>DATA MATCH TO INPUT ID NO.  9113
                              OMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.5597E 07	0.2637E 07	1407.4	1.635	0.204
FEB	1017.4	376.5	51.7	0.4066E 07	0.2382E 07	1838.5	1.445	0.321
MAR	1456.3	370.3	55.1	0.3995E 07	0.2637E 07	2458.1	1.222	0.427
APR	1922.1	291.5	55.3	0.3148E 07	0.2552E 07	3095.3	1.035	0.530
MAY	2211.3	222.0	58.0	0.2398E 07	0.2637E 07	3553.7	0.917	0.610
JUN	2350.0	138.2	61.0	0.1493E 07	0.2552E 07	3750.2	0.869	0.702
JUL	2322.5	110.2	61.8	0.1190E 07	0.2637E 07	3660.4	0.891	0.752
AUG	2052.6	91.2	62.4	0.9850E 06	0.2637E 07	3287.3	0.984	0.762
SEP	1701.2	75.6	63.4	0.8165E 06	0.2552E 07	2698.9	1.153	0.762
OCT	1212.0	151.3	60.4	0.1634E 07	0.2637E 07	2037.5	1.381	0.570
NOV	822.2	307.4	54.6	0.3320E 07	0.2552E 07	1510.1	1.609	0.325
DEC	647.0	453.0	49.1	0.5324E 07	0.2637E 07	1279.6	1.721	0.199
TOTAL		3145.4		0.3397E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.456

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	120.16	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.121E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	34.94	STORAGE SIDE CAPACITY (BTU/HR F).......	0.320E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0453	COLLECTOR SIDE CONVECTION COEFF.........	1287.5952
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0535	STORAGE SIDE CONVECTION COEFFICIENT	3399.4219
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1164	COLLECTOR SIDE FLOW RATE (GPM)	2.4765
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.4241	STORAGE SIDE FLOW RATE (GPM)	64.3116
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.0305	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
HEAT EXCHANGER LENGTH (FT)	70.63	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.5352
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9306
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0628	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.297E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0083	TOTAL ENERGY DEMAND (BTU/YEAR)	0.650E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.396E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4561
STORAGE SIDE REYNOLDS NUMBER	0.152E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.128E 04
CAPACITY RATIO (CMIN/CMAX).............	0.0377	HEX COEFFICIENT (BTU/HR F FT**2)........	323.66
FLOW PARAMETER Z2(GCP/FRUL)............	9.6843	TOTAL INSTALLATION COST ($)	3607.13
FLOW PARAMETER Z1(GCP/FRPUL)............	9.13	COLLECTOR FLOW FACTOR(FPP)...............	0.9474

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*              S O L O A D - 1                      *
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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN   *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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            >>>>>DATA MATCH TO OUTPUT ID NO.  9213
                             IMCD-1 LWK AUGUST 1979


LOCATION       OAKLAND   CALIF.    COLLECTOR SOLARMETICS                  STUDY APPROACH          ANALYSIS
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LOCATION INDEX......          9    COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.73      SLOPE:                               ------------------
MEAN TEMPERATURE....      56.59      PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)    1535.21      INTERCEPT:                           SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....    3145.40      PARAMETER,FRTA....       0.6910      DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....      55.00    BASE COST,$/FT**2...      12.98        INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                            SELECTED PARAMETERS
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TYPE ENERGY BASE.........................          OIL  COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1   OIL      0.70   0.90($/GAL)  142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2   ELE      0.99   0.05($/KWH)    3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3   GAS      0.70   0.40($/THM)  100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........         62.09
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
-------------------------                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
                                                        COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00    ESTIMATED GROUND REFLECTANCE...........,          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS  (PER)..............        6.00    ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00    ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......          0.00
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*                 S O L D A D - 1                 *
*                                                 *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
*   ---          -            -          -        *
*     RESULTS OF ANALYSIS FOR OAKLAND    CALIF.   *
*                                                 *
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              >>>>>DATA MATCH TO INPUT ID NO.   9213
                           OMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
-----	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2	---------	-------
JAN	707.9	518.2	48.3	0.5597E 07	0.2637E 07	1407.4	1.668	0.316
FEB	1017.4	376.5	51.7	0.4066E 07	0.2382E 07	1838.5	1.464	0.476
MAR	1456.3	370.3	53.1	0.3799E 07	0.2637E 07	2458.1	1.225	0.610
APR	1922.1	291.5	55.3	0.3148E 07	0.2552E 07	3095.3	1.025	0.728
MAY	2211.3	222.0	58.0	0.2398E 07	0.2637E 07	3553.7	0.900	0.808
JUN	2350.0	138.2	61.0	0.1493E 07	0.2552E 07	3750.2	0.850	0.893
JUL	2322.5	110.2	61.8	0.1190E 07	0.2637E 07	3660.4	0.872	0.937
AUG	2052.6	91.2	62.4	0.9350E 06	0.2637E 07	3287.3	0.971	0.947
SEP	1701.2	75.6	63.4	0.8165E 06	0.2552E 07	2698.9	1.151	0.951
OCT	1212.0	151.3	60.4	0.1634E 07	0.2637E 07	2037.5	1.395	0.775
NOV	822.2	307.4	54.6	0.3320E 07	0.2552E 07	1510.1	1.639	0.484
DEC	647.0	493.0	49.1	0.5324E 07	0.2637E 07	1279.6	1.759	0.310
TOTAL		3145.4		0.3397E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.621

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	192.13
COLLECTOR TILT ANGLE (DEG) ....>>>	37.79
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0373
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0630
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1250
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.4578
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.8383
HEAT EXCHANGER LENGTH (FT)	81.71
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0620
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0057
COLLECTOR SIDE REYNOLDS NUMBER..........	0.506E 05
STORAGE SIDE REYNOLDS NUMBER	0.156E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0535
FLOW PARAMETER Z2(GPM/FPUL)..............	9.7934
FLOW PARAMETER Z1(GCP/FRPUL).............	9.28

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.195E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.365E 05
COLLECTOR SIDE CONVECTION COEFF.........	1238.0464
STORAGE SIDE CONVECTION COEFFICIENT	3488.8645
COLLECTOR SIDE FLOW RATE (GPM)	4.0042
STORAGE SIDE FLOW RATE (GPM)	73.3488
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3818
HEAT EXCHANGER EFFECTIVENESS............	0.9060
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.404E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.650E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6210
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.383E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	324.59
TOTAL INSTALLATION COST ($)	4723.78
COLLECTOR FLOW FACTOR(FPP).............	0.9480

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                    S O L I A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

          DESIGN DATA OPTIONS/INPUTS SUMMARY

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          >>>>>DATA MATCH TO OUTPUT ID NO.  9221
                     IMOD-1 LWK AUGUST 1979


LOCATION       OAKLAND   CALIF.     COLLECTOR AMERICAN SUN                       STUDY APPROACH          ANALYSIS

LOCATION INDEX......          9     COLLECTOR TEST RESULTS,                      ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.73       SLOPE:
MEAN TEMPERATURE....      56.59       PARAMETER,FRUL....       1.0390
INSOL(BTU/DAY FT**2)    1535.21       INTERCEPT:                                 SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,FLC.....    3145.40       PARAMETER,FRTA....       0.6380            DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...         6.55            INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS

TYPE ENERGY BASE.......................           OIL    COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2   ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3   GAS     0.70   0.40($/THM)  100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                         STORAGE FLUID DENSITY(LB/FT**3).........        62.00
HEAT LOAD CHARACTERISTICS                                STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
                                                         STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3840
                                                         COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                         STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.25    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00    ESTIMATED GROUND REFLECTANCE...........,         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........     30000.00    ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00    ESTIMATED CORRECTION FOR TAU ALPHA PROD.         0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...         20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............         6.00    ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE LOAD EFFECTIVENESS.           1.00    ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                         MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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S O L A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>>DATA MATCH TO INPUT ID NO. 9221
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	513.2	48.3	0.1555E 08	0.2637E 07	1407.4	1.693	0.283
FEB	1017.4	376.5	51.7	0.1130E 08	0.2382E 07	1838.5	1.478	0.445
MAR	1456.3	370.3	53.1	0.1111E 08	0.2637E 07	2458.1	1.225	0.580
APR	1922.1	291.5	55.3	0.3745E 07	0.2552E 07	3095.3	1.015	0.708
MAY	2211.3	222.0	58.0	0.5660E 07	0.2637E 07	3553.7	0.884	0.811
JUN	2350.0	138.2	61.0	0.4146E 07	0.2552E 07	3750.2	0.831	0.925
JUL	2322.5	110.2	61.8	0.3306E 07	0.2637E 07	3660.4	0.854	0.976
AUG	2057.6	91.2	62.4	0.2736E 07	0.2637E 07	3287.3	0.958	0.993
SEP	1701.2	75.6	63.4	0.2268E 07	0.2552E 07	2698.9	1.147	1.000
OCT	1212.0	151.3	60.4	0.4539E 07	0.2637E 07	2037.5	1.405	0.827
NOV	822.2	307.4	54.6	0.9222E 07	0.2552E 07	1510.1	1.663	0.474
DEC	647.0	493.0	49.1	0.1479E 08	0.2637E 07	1279.6	1.790	0.281
TOTAL		3145.4		0.9436E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.584

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	431.14
COLLECTOR TILT ANGLE (DEG) ....>>>	40.29
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0700
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0840
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1432
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.9445
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.4722
HEAT EXCHANGER LENGTH (FT)	33.10
///////////////////CONSTRAINTS/////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0641
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER............	0.795E 05
STORAGE SIDE REYNOLDS NUMBER	0.177E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0831
FLOW PARAMETER Z2(STEP/FRHL)...............	9.6773
FLOW PARAMETER Z1(STEP/FRHL)...............	0.17

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.424E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.510E 05
COLLECTOR SIDE CONVECTION COEFF..........	1289.9519
STORAGE SIDE CONVECTION COEFFICIENT	3677.7405
COLLECTOR SIDE FLOW RATE (GPM)	8.6978
STORAGE SIDE FLOW RATE (GPM)	102.3435
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2428
HEAT EXCHANGER EFFECTIVENESS...............	0.8031
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.743E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.125E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.5844
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.786E 04
HEX COEFFICIENT (BTU/HR F FT**2).........	328.73
TOTAL INSTALLATION COST ($)	7600.09
COLLECTOR FLOW FACTOR(FPP)...............	0.9474

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*                     S O L O A D - 1                          *
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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN              *
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*         DESIGN DATA OPTIONS/INPUTS SUMMARY                   *
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                   >>>>>DATA MATCH TO OUTPUT ID NO.  9222
                                  (MOD-1 LWK AUGUST 1979


LOCATION       OAKLAND   CALIF.      COLLECTOR AMERICAN SUN                      STUDY APPROACH          ANALYSIS
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LOCATION INDEX.......         9      COLLECTOR TEST RESULTS,                     ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.73        SLOPE:                                    ------------------
MEAN TEMPERATURE....      56.59        PARAMETER,FRUL....      1.0390
INSOL(BTU/DAY FT**2)    1535.21        INTERCEPT:                                SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,FLD.....    3145.40        PARAMETER,FRTA....      0.6380            DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....      55.00      BASE COST,$/FT**2...        6.55            INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
----------------------------                              -------------------

TYPE ENERGY BASE..........................         OIL    COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX  TYPE EFFICIENCY    COST          HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS     0.70    0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........         104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........         62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.17     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00     ESTIMATED GROUND REFLECTANCE...........,          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........     20399.99     ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00     ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............         6.00     ESTIMATED HEX COST ($/FT**2) ...........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00     ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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S I L O A D - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>>DATA MATCH TO INPUT ID NO. 9222
JMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.1057E 08	0.2637E 07	1407.4	1.688	0.305
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.476	0.471
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.225	0.608
APR	1922.1	291.5	55.3	0.5947E 07	0.2552E 07	3095.3	1.017	0.733
MAY	2211.0	222.0	58.0	0.4529E 07	0.2637E 07	3553.7	0.887	0.825
JUN	2356.0	133.2	61.0	0.2819E 07	0.2552E 07	3750.2	0.835	0.924
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.858	0.970
AUG	2052.6	91.2	62.4	0.1860E 07	0.2637E 07	3287.3	0.961	0.984
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.148	0.993
OCT	1212.0	151.3	60.4	0.3087E 07	0.2637E 07	2037.5	1.403	0.824
NOV	822.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.659	0.493
DEC	647.0	493.0	49.1	0.1006E 08	0.2637E 07	1279.6	1.784	0.301
TOTAL		3145.4		0.6417E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.611

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	353.73
COLLECTOR TILT ANGLE (DEG) ....>>>	39.80
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0716
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0766
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1384
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.8357
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.5490
HEAT EXCHANGER LENGTH (FT)	32.38
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0618
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.701E 05
STORAGE SIDE REYNOLDS NUMBER	0.162E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0782
FLOW PARAMETER Z2(GPP/FPUL)............	9.7566
FLOW PARAMETER Z1(GLF/FRPUL)...........	9.25

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.338E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.432E 05
COLLECTOR SIDE CONVECTION COEFF.........	1286.5342
STORAGE SIDE CONVECTION COEFFICIENT	3565.4451
COLLECTOR SIDE FLOW RATE (GPM)	6.9361
STORAGE SIDE FLOW RATE (GPM)	86.8246
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2602
HEAT EXCHANGER EFFECTIVENESS............	0.8213
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.582E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.952E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6111
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.625E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	327.82
TOTAL INSTALLATION COST ($)	6024.39
COLLECTOR FLOW FACTOR(FPP)..............	0.9478

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                    S O L I A D - 1

      SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

            DESIGN DATA OPTIONS/INPUTS SUMMARY

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             >>>>>DATA MATCH TO OUTPUT ID NO.  9223
                        IMOD-1 LWK AUGUST 1979


LOCATION        OAKLAND   CALIF.     COLLECTOR AMERICAN SUN            STUDY APPROACH          ANALYSIS

LOCATION INDEX......           9     COLLECTOR TEST RESULTS,           ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.73       SLOPE:
MEAN TEMPERATURE....       56.59       PARAMETER,FRUL ....     1.0390
INSOL(BTU/DAY FT**2)     1535.21       INTERCEPT:                      SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HLL.....     3145.40       PARAMETER,FRTA....      0.6380  DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00     BASE COST,$/FT**2...        6.55  INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS

TYPE ENERGY BASE..............................    OIL     COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)       COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)       COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)       STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                          COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09      ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00      ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99      ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP.  ...     140.00      ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00      ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............        6.00      ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00      ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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*              S O L O A D - 1                      *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
*                                                   *
*      RESULTS OF ANALYSIS FOR OAKLAND   CALIF.     *
*                                                   *
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                  >>>>>DATA MATCH TO INPUT ID NO.  9223
                                 OMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.5597E 07	0.2637E 07	1407.4	1.680	0.341
FEB	1017.4	376.5	51.7	0.4066E 07	0.2382E 07	1838.5	1.471	0.512
MAR	1456.3	370.3	53.1	0.3999E 07	0.2637E 07	2458.1	1.225	0.650
APR	1922.1	291.5	55.3	0.3148E 07	0.2552E 07	3095.3	1.020	0.765
MAY	2211.3	222.0	58.0	0.2398E 07	0.2637E 07	3553.7	0.893	0.839
JUN	2350.0	138.2	61.0	0.1493E 07	0.2552E 07	3750.2	0.841	0.914
JUL	2322.5	110.2	61.8	0.1190E 07	0.2637E 07	3660.4	0.864	0.952
AUG	2052.6	91.2	62.4	0.9850E 06	0.2637E 07	3287.3	0.965	0.961
SEP	1701.2	75.6	63.4	0.3155E 06	0.2552E 07	2698.9	1.149	0.966
OCT	1212.0	151.3	60.4	0.1634E 07	0.2637E 07	2037.5	1.400	0.809
NOV	822.2	307.4	54.6	0.3320E 07	0.2552E 07	1510.1	1.651	0.519
DEC	647.0	493.0	49.1	0.5324E 07	0.2637E 07	1279.6	1.774	0.334
TOTAL		3145.4		0.3397E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.650

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	239.11
COLLECTOR TILT ANGLE (DEG) ....>>>	38.96
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0705
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0781
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1386
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.8777
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.3069
HEAT EXCHANGER LENGTH (FT)	70.73
////////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0604
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0076
COLLECTOR SIDE REYNOLDS NUMBER..........	0.518E 05
STORAGE SIDE REYNOLDS NUMBER	0.165E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0554
FLOW PARAMETER Z2(GCP/FRUL).............	9.9061
FLOW PARAMETER Z1(GCP/FRPUL)............	9.40

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.246E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.444E 05
COLLECTOR SIDE CONVECTION COEFF.........	1026.0884
STORAGE SIDE CONVECTION COEFFICIENT	3691.3235
COLLECTOR SIDE FLOW RATE (GPM)	5.0462
STORAGE SIDE FLOW RATE (GPM)	89.1481
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0211
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3728
HEAT EXCHANGER EFFECTIVENESS.............	0.8514
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.423E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.650E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6498
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.459E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	309.07
TOTAL INSTALLATION COST ($)	+328.74
COLLECTOR FLOW FACTOR(FPP)..............	0.9486

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*                    S O L A D - 1                                *
*                                                                 *
*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                 *
*    ---                        -          -                      *
*              DESIGN DATA OPTIONS/INPUTS SUMMARY                 *
*                                                                 *
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                    >>>>>DATA MATCH TO OUTPUT ID NO.  9231
                                   1400-1 LWK AUGUST 1979
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LOCATION       OAKLAND   CALIF.      COLLECTOR FEDERAL PRISON I. D        STUDY APPROACH         ANALYSIS
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LOCATION INDEX......          9      COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.73        SLOPE:                             ------------------
MEAN TEMPERATURE....      56.59         PARAMETER,FRUL....     0.8830
INSOL(BTU/DAY FT**2)    1555.21        INTERCEPT:                         SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....    3145.40         PARAMETER,FRTA....     0.6270     DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....      55.00      BASE COST,$/FT**2...        9.40     INFLATION RATE......      0.1100
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ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS
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TYPE ENERGY BASE.............................OIL             COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY    COST         HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......         60.31
  1   OIL      0.70   0.90($/GAL)  142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2   ELE      0.99   0.05($/KWH)    3413.0(BTU/KWH)         COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3   GAS      0.70   0.40($/THM)  100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........         62.09
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
-------------------------                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
                                                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.25          ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00          ESTIMATED GROUND REFLECTANCE...........           0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   30000.00          ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00          ESTIMATED CORRECTION FOR TAU ALPHA PROD.          0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...       20.00          ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............       6.00          ESTIMATED HEX COST ($/FT**2) ...........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00          ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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S O L C A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>>DATA MATCH TO INPUT ID NO. 9231

JMHD-I LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	48.3	0.1555E 08	0.2637E 07	1407.4	1.693	0.274
FEB	1017.4	376.5	51.7	0.1130E 08	0.2382E 07	1838.5	1.478	0.425
MAR	1455.3	370.3	53.1	0.1111E 08	0.2637E 07	2458.1	1.225	0.553
APR	1922.1	291.5	55.3	0.8745E 07	0.2552E 07	3095.3	1.015	0.680
MAY	2211.3	222.0	58.0	0.6560E 07	0.2637E 07	3553.7	0.884	0.788
JUN	2350.0	138.2	61.0	0.4146E 07	0.2552E 07	3750.2	0.831	0.919
JUL	2322.5	110.2	61.8	0.3306E 07	0.2637E 07	3660.4	0.855	0.983
AUG	2052.6	91.2	62.4	0.2736E 07	0.2637E 07	3287.3	0.958	1.000
SEP	1701.2	75.6	63.4	0.2268E 07	0.2552E 07	2698.9	1.147	1.000
OCT	1212.0	151.3	60.4	0.4539E 07	0.2637E 07	2037.5	1.405	0.814
NOV	822.2	307.4	54.6	0.9222E 07	0.2552E 07	1510.1	1.663	0.456
DEC	647.0	493.0	49.1	0.1479E 08	0.2637E 07	1279.6	1.789	0.272
TOTAL		3145.4		0.9436E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.571

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	376.83
COLLECTOR TILT ANGLE (DEG) ....>>>	40.27
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0763
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0829
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1410
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3053
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.9565
HEAT EXCHANGER LENGTH (FT)	90.39
////////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0531
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0066
COLLECTOR SIDE REYNOLDS NUMBER	0.644E 05
STORAGE SIDE REYNOLDS NUMBER	0.155E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0765
FLOW PARAMETER Z2(GPM/FPUL)...............	10.0023
FLOW PARAMETER Z1(GPM/FPUL)..............	[illegible]

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.331E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.433E 05
COLLECTOR SIDE CONVECTION COEFF..........	1127.8250
STORAGE SIDE CONVECTION COEFFICIENT	3647.3506
COLLECTOR SIDE FLOW RATE (GPM)	6.7873
STORAGE SIDE FLOW RATE (GPM)	86.8915
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0181
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2318
HEAT EXCHANGER EFFECTIVENESS.............	0.8627
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.716E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.125E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.5705
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.728E 04
HEX COEFFICIENT (BTU/HR F FT**2).........	317.12
TOTAL INSTALLATION COST ($)	7838.76
COLLECTOR FLOW FACTOR(FRP)................	0.9491

S O L I A C - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 9232
IMOD-1 LWK AUGUST 1979

LOCATION   OAKLAND   CALIF.

LOCATION INDEX......	9
LATITUDE,DEGREES....	37.73
MEAN TEMPERATURE....	56.59
INSOL (BTU/DAY FT**2)	1535.21
LOAD FACTOR,HLL.....	3145.40
MEAN GROUND TEMP....	55.00

COLLECTOR FEDERAL PRISON I. D

COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	0.8830
INTERCEPT:	
PARAMETER,FRTA....	0.6270
BASE COST,$/FT**2...	9.40

STUDY APPROACH   ANALYSIS

ECONOMIC ESTIMATES

SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE.......................... OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR OAKLAND CALIF.

>>>>>DATA MATCH TO INPUT ID NO. 9252
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	707.9	518.2	46.3	0.1057E 08	0.2637E 07	1407.4	1.684	0.296
FEB	1017.4	376.5	51.7	0.7681E 07	0.2382E 07	1838.5	1.473	0.455
MAR	1456.3	370.3	53.1	0.7554E 07	0.2637E 07	2458.1	1.225	0.587
APR	1922.1	291.5	55.3	0.5947E 07	0.2552E 07	3095.3	1.019	0.712
MAY	2211.3	222.0	58.0	0.4529E 07	0.2637E 07	3553.7	0.890	0.812
JUN	2350.0	138.2	61.0	0.2819E 07	0.2552E 07	3750.2	0.838	0.925
JUL	2322.5	110.2	61.8	0.2248E 07	0.2637E 07	3660.4	0.861	0.981
AUG	2052.6	91.2	62.4	0.1860E 07	0.2637E 07	3287.3	0.963	1.000
SEP	1701.2	75.6	63.4	0.1542E 07	0.2552E 07	2698.9	1.149	1.000
OCT	1212.0	151.3	60.4	0.3087E 07	0.2637E 07	2037.5	1.402	0.816
NOV	822.2	307.4	54.6	0.6271E 07	0.2552E 07	1510.1	1.654	0.479
DEC	647.0	493.0	49.1	0.1006E 08	0.2637E 07	1275.6	1.778	0.293
TOTAL		3145.4		0.6417E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.602

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	301.78
COLLECTOR TILT ANGLE (DEG) ....>>>	39.34
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0518
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0687
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1324
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.9229
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.8640
HEAT EXCHANGER LENGTH (FT)	30.38
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0637
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0069
COLLECTOR SIDE REYNOLDS NUMBER..........	0.6195E 05
STORAGE SIDE REYNOLDS NUMBER	C.1711E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0641
FLOW PARAMETER Z2(GCF/FRUL)............	9.6726
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.16

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.258E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	C.402E 05
COLLECTOR SIDE CONVECTION COEFF.........	1349.0156
STORAGE SIDE CONVECTION COEFFICIENT	3463.4609
COLLECTOR SIDE FLOW RATE (GPM)	5.2845
STORAGE SIDE FLOW RATE (GPM)	50.6978
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0175
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2674
HEAT EXCHANGER EFFECTIVENESS............	0.8557
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.573E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.952E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6020
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.581E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	331.58
TOTAL INSTALLATION COST ($)	6302.05
COLLECTOR FLOW FACTOR(FPP).............	0.9474

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*              S O L O A D - 1                    *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN   *
*                                                 *
*       DESIGN DATA OPTIONS/INPUTS SUMMARY        *
*                                                 *
* * * * * * * * * * * * * * * * * * * * * * * * * *
                 >>>>>DATA MATCH TO OUTPUT ID NO. 10111
                          IMOD-1 LWK AUGUST 1979


LOCATION     BRYCE CANYON UT     COLLECTOR SOLARNETICS                  STUDY APPROACH         ANALYSIS
--------                         ---------                              --------------

LOCATION INDEX......        10   COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.70     SLOPE:                               ------------------
MEAN TEMPERATURE....     40.27     PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)   1739.77     INTERCEPT:                           SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....   9044.29     PARAMETER,FRTA....      0.6910       DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....     55.00   BASE COST,$/FT**2...       12.98       INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                         SELECTED PARAMETERS
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TYPE ENERGY BASE.........................    OIL   COLLECTOR FLUID MEAN TEMPERATURE.........      176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE  COLLECTOR FLUID DENSITY(LB/FT**3)........       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL) COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH) COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM) STORAGE FLUID MEAN TEMPERATURE .........     104.00
                                                   STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                   STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                          STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                          COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                   STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                   HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.25 ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00 ESTIMATED GROUND REFLECTANCE...........        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  30000.00 ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00 ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00 ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............      6.00 ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00 ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                   MAINTENANCE (% INSTALLED COST/YR).......        0.01
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SOLUAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10111
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
-----	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.4236E 08	0.2637E 07	1408.9	1.879	0.246
FEB	1236.0	1186.0	23.2	0.3558E 08	0.2382E 07	1839.9	1.578	0.308
MAR	1685.0	1114.0	29.1	0.3342E 08	0.2637E 07	2459.2	1.256	0.389
APR	2133.0	821.4	37.6	0.2464E 08	0.2552E 07	3095.9	1.001	0.488
MAY	2454.0	542.0	47.5	0.1626E 08	0.2637E 07	3553.9	0.850	0.649
JUN	2655.0	249.0	56.9	0.7470E 07	0.2552E 07	3750.1	0.788	0.925
JUL	2424.0	76.9	63.2	0.2307E 07	0.2637E 07	3660.5	0.819	1.000
AUG	2157.0	144.4	60.6	0.4332E 07	0.2637E 07	3287.7	0.934	1.000
SEP	1920.0	370.0	52.7	0.1110E 08	0.2552E 07	2699.9	1.159	0.829
OCT	1465.0	710.0	42.1	0.2130E 08	0.2637E 07	2038.8	1.491	0.569
NOV	1016.0	1060.0	29.6	0.3180E 08	0.2552E 07	1511.6	1.816	0.337
DEC	818.2	1358.6	21.2	0.4076E 08	0.2637E 07	1281.1	1.987	0.238
TOTAL		9044.3		0.2713E 09	0.3105E 08			
						>>>WEIGHTED	AVERAGE	0.431

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	487.11	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.490E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	44.63	STORAGE SIDE CAPACITY (BTU/HR F).......	0.377E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0956	COLLECTOR SIDE CONVECTION COEFF.........	1028.8706
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.1006	STORAGE SIDE CONVECTION COEFFICIENT	4185.7383
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1765	COLLECTOR SIDE FLOW RATE (GPM)	10.0398
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1178	STORAGE SIDE FLOW RATE (GPM)	176.0220
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	23.7328	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
HEAT EXCHANGER LENGTH (FT)	125.79	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3614
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9018
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0759	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.130E 09
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.302E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.760E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4311
STORAGE SIDE REYNOLDS NUMBER	0.255E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.690E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0559	HEX COEFFICIENT (BTU/HR F FT**2)........	311.52
FLOW PARAMETER Z2(GCP/FRUL).............	9.6848	TOTAL INSTALLATION COST ($)	14605.08
FLOW PARAMETER Z1(GCP/FRPUL)............	7.18	COLLECTOR FLOW FACTOR(FPP)..............	0.9474

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

\>>>>>DATA MATCH TO OUTPUT ID NO. 10112
IMOD-1 LWK AUGUST 1979

LOCATION	BRYCE CANYON UT
LOCATION INDEX......	10
LATITUDE,DEGREES....	37.70
MEAN TEMPERATURE....	40.27
INSOL(BTU/DAY FT**2)	1739.77
LOAD FACTOR,HDD.....	9044.29
MEAN GROUND TEMP....	55.00

COLLECTOR SOLARNETICS	
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	1.0380
INTERCEPT:	
PARAMETER,FRTA....	0.6910
BASE COST,$/FT**2...	12.98

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.1150
INFLATION RATE......	0.1050

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE........................ OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE...........,	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.01

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10112
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.2880E 08	0.2637E 07	1408.9	1.875	0.252
FEB	1236.0	1186.0	23.2	0.2419E 08	0.2382E 07	1839.9	1.576	0.315
MAR	1685.0	1114.0	29.1	0.2273E 08	0.2637E 07	2459.2	1.256	0.397
APR	2133.0	821.4	37.6	0.1676E 08	0.2552E 07	3095.9	1.003	0.494
MAY	2454.0	542.0	47.5	0.1106E 08	0.2637E 07	3553.9	0.853	0.648
JUN	2655.0	249.0	56.9	0.5080E 07	0.2552E 07	3750.1	0.792	0.906
JUL	2424.0	76.9	63.2	0.1569E 07	0.2637E 07	3660.5	0.823	1.000
AUG	2157.0	144.4	60.6	0.2946E 07	0.2637E 07	3287.7	0.937	1.000
SEP	1920.0	370.0	52.7	0.7548E 07	0.2552E 07	2655.9	1.160	0.818
OCT	1465.0	710.0	42.1	0.1448E 08	0.2637E 07	2038.8	1.490	0.571
NOV	1016.0	1060.0	29.6	0.2162E 08	0.2552E 07	1511.6	1.812	0.343
DEC	818.2	1358.6	21.2	0.2772E 08	0.2637E 07	1281.1	1.982	0.243
TOTAL		9044.3		0.1845E 09	0.3105E 08			
						>>>WEIGHTED	AVERAGE	0.442

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	351.69	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.351E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	44.21	STORAGE SIDE CAPACITY (BTU/HR F).......	0.587E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0817	COLLECTOR SIDE CONVECTION COEFF.........	1044.5513
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0873	STORAGE SIDE CONVECTION COEFFICIENT	3965.6694
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1523	COLLECTOR SIDE FLOW RATE (GPM)	7.1982
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.0556	STORAGE SIDE FLOW RATE (GPM)	117.7682
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	21.4669	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
HEAT EXCHANGER LENGTH (FT)	95.55	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3349
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.8780
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0655	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.952E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0056	TOTAL ENERGY DEMAND (BTU/YEAR)	0.216E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.637E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4416
STORAGE SIDE REYNOLDS NUMBER	0.197E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.517E 04
CAPACITY RATIO (CMIN/CMAX)...............	0.0599	HEX COEFFICIENT (BTU/HR F FT**2)........	311.95
FLOW PARAMETER Z2(GCP/FRUL).............	9.6175	TOTAL INSTALLATION COST ($)	10528.49
FLOW PARAMETER Z1(GCP/FRPUL)............	9.11	COLLECTOR FLOW FACTOR(FPP)..............	0.9471

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                    S O L I A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

            DESIGN DATA OPTIONS/INPUTS SUMMARY

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               >>>>>DATA MATCH TO OUTPUT ID NO. 10113
                                IMOD-1 LWK AUGUST 1979
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LOCATION       BRYCE CANYON  UT     COLLECTOR SOLARMETICS                       STUDY APPROACH           ANALYSIS
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LOCATION INDEX......        10      COLLECTOR TEST RESULTS,                     ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.70        SLOPE:                                    ------------------
MEAN TEMPERATURE....     40.27         PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)   1739.77        INTERCEPT:                                SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....   9044.29         PARAMETER,FRTA....       0.6910          DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....     55.00      BASE COST,$/FT**2...       12.98            INFLATION RATE......      0.1050
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ENERGY COMPARATIVE ESTIMATES                                     SELECTED PARAMETERS
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TYPE ENERGY BASE.........................           OIL          COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE             COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1   OIL      0.70    0.90($/GAL) 142000.0(BTU/GAL)             COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE      0.99    0.05($/KWH)   3413.0(BTU/KWH)             COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS      0.70    0.40($/THM) 100000.0(BTU/THM)             STORAGE FLUID MEAN TEMPERATURE .........      104.00
                                                                 STORAGE FLUID DENSITY(LB/FT**3).........       62.05
HEAT LOAD CHARACTERISTICS                                        STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                                        STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                                 STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                                 HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09             ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00             ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99             ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00             ESTIMATED CORRECTION FOR TAU ALPHA PROD.        0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...        20.00             ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)..............         3.00             ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00             ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                                 MAINTENANCE (% INSTALLED COST/YR).......        0.01
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*                  S O L O A D - 1                *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
*   ---          -            -             -     *
*     RESULTS OF ANALYSIS FOR BRYCE CANYON   UT   *
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                     >>>>>DATA MATCH TO INPUT ID NO. 10113
                              JMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.1525E 08	0.2637E 07	1408.9	1.862	0.284
FEB	1236.0	1186.0	23.2	0.1281E 08	0.2382E 07	1839.9	1.570	0.354
MAR	1685.0	1114.0	29.1	0.1203E 08	0.2637E 07	2459.2	1.257	0.442
APR	2133.0	821.4	37.6	0.8871E 07	0.2552E 07	3095.9	1.010	0.540
MAY	2454.0	542.0	47.5	0.5854E 07	0.2637E 07	3553.9	0.863	0.682
JUN	2655.0	249.0	56.9	0.2689E 07	0.2552E 07	3750.1	0.803	0.898
JUL	2424.0	76.9	63.2	0.8305E 06	0.2637E 07	3660.5	0.833	1.000
AUG	2157.0	144.4	60.6	0.1560E 07	0.2637E 07	3287.7	0.944	0.968
SEP	1920.0	370.0	52.7	0.3996E 07	0.2552E 07	2699.9	1.163	0.826
OCT	1465.0	710.0	42.1	0.7668E 07	0.2637E 07	2038.8	1.486	0.608
NOV	1016.0	1060.0	29.6	0.1145E 08	0.2552E 07	1511.6	1.800	0.379
DEC	818.2	1353.6	21.2	0.1467E 08	0.2637E 07	1281.1	1.966	0.273
TOTAL		9044.3		0.9768E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.488

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	230.38
COLLECTOR TILT ANGLE (DEG) ....>>>	42.95
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0638
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0706
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1372
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2870
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.1926
HEAT EXCHANGER LENGTH (FT)	92.29
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0666
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0068
COLLECTOR SIDE REYNOLDS NUMBER..........	0.535E 05
STORAGE SIDE REYNOLDS NUMBER	0.190E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0470
FLOW PARAMETER Z2(UCP/FRUL)............	9.6287
FLOW PARAMETER Z1(UCP/FRPUL)...........	9.12

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.230E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.490E 05
COLLECTOR SIDE CONVECTION COEFF.........	1163.5361
STORAGE SIDE CONVECTION COEFFICIENT	3800.2976
COLLECTOR SIDE FLOW RATE (GPM)	4.7209
STORAGE SIDE FLOW RATE (GPM)	98.4401
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4273
HEAT EXCHANGER EFFECTIVENESS...........	0.9184
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.629E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.129E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4883
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.346E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	321.34
TOTAL INSTALLATION COST ($)	6911.36
COLLECTOR FLOW FACTOR(FPP)..............	0.9471

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                    S O L U A D - 1
         SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
         ---          -            -          -
              DESIGN DATA OPTIONS/INPUTS SUMMARY

                          >>>>>DATA MATCH TO OUTPUT ID NO. 10213
                                  IMOD-1 LWK AUGUST 1979


LOCATION        BRYCE CANYON  UT      COLLECTOR SOLARNETICS              STUDY APPROACH          ANALYSIS
--------                              ---------                          --------------

LOCATION INDEX.......         10      COLLECTOR TEST RESULTS,            ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.70        SLOPE:                           ------------------
MEAN TEMPERATURE....       40.27        PARAMETER,FRUL....     1.0380
INSOL(BTU/DAY FT**2)     1739.77        INTERCEPT:                       SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....     9044.29        PARAMETER,FRTA....     0.6910    DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00      BASE COST,$/FT**2...     12.98     INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
----------------------------                          -------------------

TYPE ENERGY BASE..............................  OIL   COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1   OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)   COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2   ELL      0.99   0.05($/KWH)   3413.0(BTU/KWH)   COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3   GAS      0.70   0.40($/THM) 100000.0(BTU/THM)   STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00    ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99    ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USE OF (GAL/PER) ...     20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............      0.00    ESTIMATED HEX COST ($/FT**2) ...........       5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00    ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......       0.00
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10213
DMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.1525E 08	0.2637E 07	1408.9	1.914	0.419
FEB	1236.0	1186.0	23.2	0.1281E 08	0.2382E 07	1839.9	1.593	0.506
MAR	1685.0	1114.0	29.1	0.1203E 08	0.2637E 07	2459.2	1.249	0.605
APR	2133.0	821.4	37.6	0.8871E 07	0.2552E 07	3095.9	0.978	0.703
MAY	2454.0	542.0	47.5	0.5854E 07	0.2637E 07	3553.9	0.819	0.835
JUN	2655.0	249.0	56.9	0.2689E 07	0.2552E 07	3750.1	0.754	0.957
JUL	2424.0	76.9	63.2	0.8305E 06	0.2637E 07	3660.5	0.787	1.000
AUG	2157.0	144.4	60.6	0.1560E 07	0.2637E 07	3287.7	0.908	1.000
SEP	1920.0	370.0	52.7	0.3996E 07	0.2552E 07	2699.9	1.145	0.982
OCT	1465.0	710.0	42.1	0.7668E 07	0.2637E 07	2038.8	1.499	0.803
NOV	1016.0	1060.0	29.6	0.1145E 08	0.2552E 07	1511.6	1.846	0.543
DEC	818.2	1358.6	21.2	0.1467E 08	0.2637E 07	1281.1	2.029	0.406
TOTAL		9044.3		0.9768E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.632

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	355.55	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.383E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	48.50	STORAGE SIDE CAPACITY (BTU/HR F).......	0.466E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0719	COLLECTOR SIDE CONVECTION COEFF.........	1411.7432
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0769	STORAGE SIDE CONVECTION COEFFICIENT	3581.1611
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1416	COLLECTOR SIDE FLOW RATE (GPM)	7.8504
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.3116	STORAGE SIDE FLOW RATE (GPM)	93.6463
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.7959	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0221
HEAT EXCHANGER LENGTH (FT)	90.70	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2634
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8204
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0647	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.814E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.129E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.790E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6322
STORAGE SIDE REYNOLDS NUMBER	0.172E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.858E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0821	HEX COEFFICIENT (BTU/HR F FT**2)........	335.52
FLOW PARAMETER Z2(GCP/FRUL).............	10.3750	TOTAL INSTALLATION COST ($)	8708.16
FLOW PARAMETER Z1(GCP/FRPUL)............	9.87	COLLECTOR FLOW FACTOR(FPP).............	0.9510

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*                         S O L O A D - 1                          *
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*     SOLAR ENERGY OPTIMIZATION ANALYSIS IN DESIGN                 *
*     ---                                                          *
*          DESIGN DATA OPTIONS/INPUTS SUMMARY                      *
*                                                                  *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 10221
                                      IMCD-1 LWK AUGUST 1979


LOCATION        BRYCE CANYON  UT       COLLECTOR AMERICAN SUN               STUDY APPROACH         ANALYSIS
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LOCATION INDEX......         10        COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.70          SLOPE:                             ------------------
MEAN TEMPERATURE....      40.27          PARAMETER,FRUL....    1.0390
INSOL(BTU/DAY FT**2)    1739.77          INTERCEPT:                         SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....    9044.29          PARAMETER,FRTA....    0.6380       DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....      55.00        BASE COST,$/FT**2...      6.55       INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                              SELECTED PARAMETERS
----------------------------                              -------------------

TYPE ENERGY BASE..........................        OIL     COLLECTOR FLUID MEAN TEMPERATURE........    176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE         COLLECTOR FLUID DENSITY(LB/FT**3).......     60.81
  1   OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).    1.0000
  2   ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)   0.3870
  3   GAS      0.70   0.40($/THM),100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........    104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........     62.09
                                                          STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...    1.0000
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).    0.3640
-------------------------                                 COLLECTOR SIDE FOULING FACTOR(HR F/BTU)     0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                          HEX TUBE CONDUCTIVITY(BTU/HR FT F)......    220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.25        ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....     15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00        ESTIMATED GROUND REFLECTANCE............,      0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  30000.00        ESTIMATED PUMPING POWER(KWH/AREAC)......    1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00        ESTIMATED CORRECTION FOR TAU ALPHA PROD.      0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00        ESTIMATED INSTALL/LABOR COST ($/AREAC)..     10.00
ESTIMATED DHW USERS (PER)...............      6.00        ESTIMATED HEX COST ($/FT**2) ...........      5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00        ESTIMATED STORAGE TANK COST($/LB STORED)      0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......    0.0010
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S I L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10221
IMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.4236E 08	0.2637E 07	1408.9	1.925	0.453
FEB	1236.0	1186.0	23.2	0.3558E 08	0.2312E 07	1839.9	1.597	0.546
MAR	1685.0	1114.0	29.1	0.3342E 08	0.2637E 07	2459.2	1.246	0.653
APR	2133.0	821.4	37.6	0.2464E 08	0.2552E 07	3095.9	0.970	0.760
MAY	2454.0	542.0	47.5	0.1626E 08	0.2637E 07	3553.9	0.808	0.898
JUN	2655.0	249.0	56.9	0.7470E 07	0.2552E 07	3750.1	0.742	1.000
JUL	2424.0	76.9	63.2	0.2307E 07	0.2637E 07	3660.5	0.776	1.000
AUG	2157.0	144.4	60.6	0.4332E 07	0.2637E 07	3287.7	0.898	1.000
SEP	1920.0	370.0	52.7	0.1110E 08	0.2552E 07	2699.9	1.140	1.000
OCT	1465.0	710.0	42.1	0.2130E 08	0.2637E 07	2038.8	1.501	0.871
NOV	1016.0	1060.0	29.6	0.3180E 08	0.2552E 07	1511.6	1.855	0.593
DEC	318.2	1358.6	21.2	0.4076E 08	0.2637E 07	1281.1	2.042	0.440
TOTAL		9044.3		0.2713E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.656

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	1100.59	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.109E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	49.55	STORAGE SIDE CAPACITY (BTU/HR F).......	0.159E 06
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.1318	COLLECTOR SIDE CONVECTION COEFF.........	1094.7612
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.1375	STORAGE SIDE CONVECTION COEFFICIENT	4364.8516
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.2310	COLLECTOR SIDE FLOW RATE (GPM)	22.3473
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.6510	STORAGE SIDE FLOW RATE (GPM)	319.6243
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	26.3040	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
HEAT EXCHANGER LENGTH (FT)	148.52	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2883
//////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8224
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0935	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.198E 09
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0057	TOTAL ENERGY DEMAND (BTU/YEAR)	0.302E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.1235E 06	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6555
STORAGE SIDE REYNOLDS NUMBER	0.347E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.219E 05
CAPACITY RATIO (CMIN/CMAX).............	0.0685	HEX COEFFICIENT (BTU/HR F FT**2)........	317.89
FLOW PARAMETER Z2(GP/FPRUL)............	9.4832	TOTAL INSTALLATION COST ($)	15975.96
FLOW PARAMETER Z1(GP/FPRUL)............	8.97	COLLECTOR FLOW FACTOR(FPP)..............	0.9463

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*                    S O L O A D - 1                        *
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*     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN          *
*     ---          -            -          -                *
*            DESIGN DATA OPTIONS/INPUTS SUMMARY             *
*                                                           *
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                      >>>>>DATA MATCH TO OUTPUT ID NO. 10222
                                     IMCD-1 LNK AUGUST 1979


LOCATION        BRYCE CANYON  UT       COLLECTOR AMERICAN SUN                  STUDY APPROACH         ANALYSIS
--------                               ---------                               --------------

LOCATION INDEX......          10       COLLECTOR TEST RESULTS,                 ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.70         SLOPE:                                ------------------
MEAN TEMPERATURE....       40.27         PARAMETER,FRUL....     1.0390
INSOL(BTU/DAY FT**2)     1739.77         INTERCEPT:                            SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....     9044.29         PARAMETER,FRTA....     0.6380         DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00       BASE COST,$/FT**2...       6.55         INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                                  SELECTED PARAMETERS
----------------------------                                  -------------------

TYPE ENERGY BASE.............................OIL              COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE           COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL    0.70   0.50($/GAL) 142000.0(BTU/GAL)            COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE    0.95   0.05($/KWH)   3413.0(BTU/KWH)            COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS    0.70   0.40($/THM) 100000.0(BTU/THM)            STORAGE FLUID MEAN TEMPERATURE ........         104.00
                                                              STORAGE FLUID DENSITY(LB/FT**3).........         62.09
                                                              STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                                     STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                                     COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                              STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                              HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.17        ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00        ESTIMATED GROUND REFLECTANCE............          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........      20399.99        ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP.  ...       140.00        ESTIMATED CORRECTION FOR TAU ALPHA PROD.          0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...         20.00        ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............          6.00        ESTIMATED HEX COST ($/FT**2) ..........           5.00
ESTIMATED STORAGE TO LOAD EFFECTIVNESS.           1.00        ESTIMATED STORAGE TANK COST($/LB STORED)          0.06
                                                              MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10222
UMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.2380E 08	0.2637E 07	1408.9	1.925	0.459
FEB	1236.0	1186.0	23.2	0.2419E 08	0.2382E 07	1839.9	1.597	0.552
MAR	1685.0	1114.0	29.1	0.2273E 08	0.2637E 07	2459.2	1.246	0.658
APR	2133.0	821.4	37.6	0.1676E 08	0.2552E 07	3095.9	0.970	0.760
MAY	2454.0	542.0	47.5	0.1106E 08	0.2637E 07	3553.9	0.808	0.892
JUN	2655.0	249.0	56.9	0.5080E 07	0.2552E 07	3750.1	0.742	1.000
JUL	2424.0	76.9	63.2	0.1569E 07	0.2637E 07	3660.5	0.776	1.000
AUG	2157.0	144.4	60.6	0.2946E 07	0.2637E 07	3287.7	0.898	1.000
SEP	1920.0	370.0	52.7	0.7548E 07	0.2552E 07	2699.9	1.140	1.000
OCT	1465.0	710.0	42.1	0.1448E 08	0.2637E 07	2038.8	1.501	0.869
NOV	1016.0	1060.0	29.6	0.2162E 08	0.2552E 07	1511.6	1.855	0.597
DEC	818.2	1358.6	21.2	0.2772E 08	0.2637E 07	1281.1	2.042	0.445
TOTAL		9044.3		0.1845E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.663

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	783.71
COLLECTOR TILT ANGLE (DEG) ....>>>	49.85
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.1032
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.1142
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1908
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.8469
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	23.1366
HEAT EXCHANGER LENGTH (FT)	136.11
////////////////////CONSTRAINTS////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0766
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0060
COLLECTOR SIDE REYNOLDS NUMBER...........	0.106E 06
STORAGE SIDE REYNOLDS NUMBER	0.250E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0816
FLOW PARAMETER Z2(GCP/FRUL)..............	9.5093
FLOW PARAMETER Z1(GCP/FPPUL).............	9.00

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.775E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.949E 05
COLLECTOR SIDE CONVECTION COEFF.........	1137.3516
STORAGE SIDE CONVECTION COEFFICIENT	4073.9055
COLLECTOR SIDE FLOW RATE (GPM)	15.8794
STORAGE SIDE FLOW RATE (GPM)	150.6151
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2432
HEAT EXCHANGER EFFECTIVENESS............	0.8425
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.143E 09
TOTAL ENERGY DEMAND (BTU/YEAR)	0.216E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6634
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.161E 05
HEX COEFFICIENT (BTU/HR F FT**2)........	323.83
TOTAL INSTALLATION COST ($)	14164.61
COLLECTOR FLOW FACTOR(FPP)..............	0.9464

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                         S O L O A D - 1
        SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
                DESIGN DATA OPTIONS/INPUTS SUMMARY
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                >>>>>DATA MATCH TO OUTPUT ID NO. 10223
                                IMOD-1 LWK AUGUST 1979

LOCATION         BRYCE CANYON  UT      COLLECTOR AMERICAN SUN              STUDY APPROACH        ANALYSIS
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LOCATION INDEX......           10      COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....        37.70        SLOPE:                            ------------------
MEAN TEMPERATURE....        40.27        PARAMETER,FRUL....    1.0350
INSOL(BTU/DAY FT**2)      1739.77        INTERCEPT:                        SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....      9044.29        PARAMETER,FRTA....    0.6380      DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....        55.00      BASE COST,$/FT**2...      6.55      INFLATION RATE......    0.1100

ENERGY COMPARATIVE ESTIMATES                                   SELECTED PARAMETERS
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TYPE ENERGY BASE.......................... OIL                 COLLECTOR FLUID MEAN TEMPERATURE........           176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE              COLLECTOR FLUID DENSITY(LB/FT**3).......            60.81
  1   OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)             COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).           1.0000
  2   ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)             COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)          0.3870
  3   GAS     0.70   0.40($/THM) 100000.0(BTU/THM)             STORAGE FLUID MEAN TEMPERATURE .........           104.00
                                                               STORAGE FLUID DENSITY(LB/FT**3).........            62.09
HEAT LOAD CHARACTERISTICS                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...           1.0000
-------------------------                                      STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).           0.3640
                                                               COLLECTOR SIDE FOULING FACTOR(HR F/BTU)            0.0010
                                                               STORAGE SIDE FOULING FACTOR(HR F/BTU)              0.0010
                                                               HEX TUBE CONDUCTIVITY(BTU/HR FT F)......           220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.09            ESTIMATED OPTIMUM STORAGE(LB/ARFAC) ....            15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00            ESTIMATED GROUND REFLECTANCE...........              0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   10799.99            ESTIMATED PUMPING POWER(KWH/ARFAC)......           1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00            ESTIMATED CORRECTION FOR TAU ALPHA PROD.             0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00            ESTIMATED INSTALL/LABOR COST ($/ARFAC)..            10.00
ESTIMATED DHW USERS (PER)...............       6.00            ESTIMATED HEX COST ($/FT**2) ..........              5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00            ESTIMATED STORAGE TANK COST($/LB STORED)             0.08
                                                               MAINTENANCE (% INSTALLED COST/YR).......           0.0010
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S O L L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10223
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.1525E 08	0.2637E 07	1408.9	1.917	0.468
FEB	1236.0	1186.0	23.2	0.1281E 08	0.2382E 07	1839.9	1.594	0.562
MAR	1685.0	1114.0	29.1	0.1203E 08	0.2637E 07	2459.2	1.248	0.666
APR	2133.0	821.4	37.6	0.8871E 07	0.2552E 07	3095.9	0.976	0.762
MAY	2454.0	542.0	47.5	0.5854E 07	0.2637E 07	3553.9	0.816	0.880
JUN	2655.0	249.0	56.9	0.2689E 07	0.2552E 07	3750.1	0.751	1.000
JUL	2424.0	76.9	63.2	0.8305E 06	0.2637E 07	3660.5	0.784	1.000
AUG	2157.0	144.4	60.6	0.1560E 07	0.2637E 07	3287.7	0.905	1.000
SEP	1920.0	370.0	52.7	0.3996E 07	0.2552E 07	2699.9	1.144	1.000
OCT	1465.0	710.0	42.1	0.7668E 07	0.2637E 07	2038.8	1.500	0.859
NOV	1016.0	1060.0	29.6	0.1145E 08	0.2552E 07	1511.6	1.848	0.601
DEC	818.2	1358.6	21.2	0.1467E 08	0.2637E 07	1281.1	2.033	0.453
TOTAL		9044.3		0.9768E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.679

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	460.19	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.461E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	48.85	STORAGE SIDE CAPACITY (BTU/HR F).......	0.707E 05
COLLECTOR SIDE TUBE LINER DIA. (FT)	0.0786	COLLECTOR SIDE CONVECTION COEFF.........	1395.5149
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0882	STORAGE SIDE CONVECTION COEFFICIENT	3810.0092
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1642	COLLECTOR SIDE FLOW RATE (GPM)	9.4548
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.3455	STORAGE SIDE FLOW RATE (GPM)	142.0402
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.9971	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
HEAT EXCHANGER LENGTH (FT)	108.47	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3087
//////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.8479
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0760	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.874E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0096	TOTAL ENERGY DEMAND (BTU/YEAR)	0.129E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.871E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6790
STORAGE SIDE REYNOLDS NUMBER	0.225E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.102E 05
CAPACITY RATIO (CMIN/CMAX)..............	0.0652	HEX COEFFICIENT (BTU/HR F FT**2)........	336.58
FLOW PARAMETER Z2(GCP/FRUL).............	9.6447	TOTAL INSTALLATION COST ($)	8313.32
FLOW PARAMETER Z1(GCP/FRPUL)............	9.14	COLLECTOR FLOW FACTOR(FPP)..............	0.9472

S O L O A D - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

\>>>>>DATA MATCH TO OUTPUT ID NO. 10231
IMOD-1 LWK AUGUST 1979

LOCATION	BRYCE CANYON UT
LOCATION INDEX......	10
LATITUDE,DEGREES....	37.70
MEAN TEMPERATURE....	40.27
INSOL(BTU/DAY FT**2)	1739.77
LOAD FACTOR,HDD.....	9344.29
MEAN GROUND TEMP....	55.00

COLLECTOR FEDERAL PRISON I. L	
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	0.8830
INTERCEPT:	
PARAMETER,FRTA....	0.6270
BASE COST,$/FT**2...	9.40

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE........................ OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELL	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.25
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	30000.00
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE...........	0.20
ESTIMATED PUMPING POWER(KWH/AREAC).....	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

\>>>>DATA MATCH TO INPUT ID NO. 10231
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.4236E 08	0.2637E 07	1408.9	1.922	0.433
FEB	1236.0	1186.0	23.2	0.3558E 08	0.2382E 07	1839.9	1.596	0.522
MAR	1685.0	1114.0	29.1	0.3342E 08	0.2637E 07	2459.2	1.247	0.628
APR	2133.0	821.4	37.6	0.2464E 08	0.2552E 07	3095.9	0.972	0.740
MAY	2454.0	542.0	47.5	0.1626E 08	0.2637E 07	3553.9	0.811	0.896
JUN	2655.0	249.0	56.9	0.7470E 07	0.2552E 07	3750.1	0.746	1.000
JUL	2424.0	75.9	63.2	0.2307E 07	0.2637E 07	3660.5	0.779	1.000
AUG	2157.0	144.4	60.6	0.4332E 07	0.2637E 07	3287.7	0.901	1.000
SEP	1920.0	270.0	52.7	0.1110E 08	0.2552E 07	2699.9	1.141	1.000
OCT	1455.0	710.0	42.1	0.2130E 08	0.2637E 07	2038.8	1.501	0.855
NOV	1016.0	1060.0	29.6	0.3183E 08	0.2552E 07	1511.6	1.852	0.570
DEC	815.2	1358.6	21.2	0.4076E 08	0.2637E 07	1281.1	2.038	0.422
TOTAL		9044.3		0.2713E 09	0.3105E 08			

\>>>WEIGHTED AVERAGE 0.638

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	995.72
COLLECTOR TILT ANGLE (DEG) ....>>>	49.46
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.1148
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.1173
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.2017
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.7335
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	23.7651
HEAT EXCHANGER LENGTH (FT)	127.40
//////////////////CONSTRAINTS//////////////////	
HEX ANNULAS DIAMETER DIFFERENCE (FT)....	0.0819
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER...........	0.100E 06
STORAGE SIDE REYNOLDS NUMBER	0.275E 06
CAPACITY RATIO (CMIN/CMAX)..................	0.0770
FLOW PARAMETER Z2(SCP/FPUL)..............	9.6265
FLOW PARAMETER Z1(SCP/FRPUL).............	9.12

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.346E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.110E 06
COLLECTOR SIDE CONVECTION COEFF..........	1145.5925
STORAGE SIDE CONVECTION COEFFICIENT	4119.7852
COLLECTOR SIDE FLOW RATE (GPM)	17.3528
STORAGE SIDE FLOW RATE (GPM)	220.6711
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0174
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2216
HEAT EXCHANGER EFFECTIVENESS...............	0.8124
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.193E 09
TOTAL ENERGY DEMAND (BTU/YEAR)	0.302E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6382
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.200E 05
HEX COEFFICIENT (BTU/HR F FT**2).........	320.86
TOTAL INSTALLATION COST ($)	20765.62
COLLECTOR FLOW FACTOR(FPP)................	0.9471

SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

\>>>>>DATA MATCH TO OUTPUT ID NO. 10232
IMOD-1 LWK AUGUST 1979

LOCATION	BRYCE CANYON UT
LOCATION INDEX......	10
LATITUDE,DEGREES....	37.70
MEAN TEMPERATURE....	40.27
INSOL(BTU/DAY FT**2)	1739.77
LOAD FACTOR,HDD.....	9044.29
MEAN GROUND TEMP....	55.00

COLLECTOR	FEDERAL PRISON I. D
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	0.8830
INTERCEPT:	
PARAMETER,FRTA....	0.6270
BASE COST,$/FT**2...	9.40

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE........................... OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	0.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE.........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3)........	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3370
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3)..........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10232
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.2880E 08	0.2637E 07	1408.9	1.921	0.441
FEB	1236.0	1186.0	23.2	0.2419E 08	0.2382E 07	1839.9	1.596	0.531
MAR	1685.0	1114.0	29.1	0.2273E 08	0.2637E 07	2459.2	1.247	0.635
APR	2135.0	821.4	37.6	0.1676E 08	0.2552E 07	3095.9	0.973	0.743
MAY	2454.0	542.0	47.5	0.1106E 08	0.2637E 07	3553.9	0.812	0.891
JUN	2655.0	245.0	56.9	0.5080E 07	0.2552E 07	3750.1	0.747	1.000
JUL	2424.0	76.9	63.2	0.1569E 07	0.2637E 07	3660.5	0.780	1.000
AUG	2157.0	144.4	60.6	0.2946E 07	0.2637E 07	3287.7	0.901	1.000
SEP	1920.0	370.0	52.7	0.7548E 07	0.2552E 07	2699.9	1.142	1.000
OCT	1465.0	710.0	42.1	0.1448E 08	0.2637E 07	2038.8	1.501	0.855
NOV	1016.0	1060.0	29.6	0.2162E 08	0.2552E 07	1511.6	1.852	0.576
DEC	818.2	1358.6	21.2	0.2772E 08	0.2637E 07	1281.1	2.038	0.429
TOTAL		9044.3		0.1845E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.648

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	707.92	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.603E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	49.37	STORAGE SIDE CAPACITY (BTU/HR F).......	0.845E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0949	COLLECTOR SIDE CONVECTION COEFF.........	1230.5281
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0999	STORAGE SIDE CONVECTION COEFFICIENT	3967.5757
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1776	COLLECTOR SIDE FLOW RATE (GPM)	12.3644
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.8929	STORAGE SIDE FLOW RATE (GPM)	169.5895
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	22.3075	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0175
HEAT EXCHANGER LENGTH (FT)	120.85	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2396
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8465
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0777	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.140E 09
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.216E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.943E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6482
STORAGE SIDE REYNOLDS NUMBER	0.245E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.148E 05
CAPACITY RATIO (CMIN/CMAX)..............	0.0714	HEX COEFFICIENT (BTU/HR F FT**2)........	326.46
FLOW PARAMETER Z2(GCP/FRUL).............	9.6476	TOTAL INSTALLATION COST ($)	14780.37
FLOW PARAMETER Z1(GCP/FRPUL)............	9.14	COLLECTOR FLOW FACTOR(FPP).............	0.9472

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                              S O L A C - I
          SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
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                DESIGN DATA OPTIONS/INPUTS SUMMARY

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                  >>>>>DATA MATCH TO OUTPUT ID NO. 10233
                                 IMOD-1 LWK AUGUST 1979


LOCATION        BRYCE CANYON  UT     COLLECTOR FEDERAL PRISON I. L      STUDY APPROACH          ANALYSIS
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LOCATION INDEX.......          10    COLLECTOR TEST RESULTS,            ECONOMIC ESTIMATES
LATITUDE,DEGREES....        37.70      SLOPE:                           ------------------
MEAN TEMPERATURE....        40.27        PARAMETER,FRUL ....    0.8830
INSOL(BTU/DAY FT**2)      1739.77      INTERCEPT:                       SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HLL.....      9041.29        PARAMETER,FR TA....    0.6270  DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....        55.00    BASE COST,$/FT**2...         9.40  INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS
----------------------------                               -------------------

TYPE ENERGY BASE.........................        OIL      COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY     COST         HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL     0.70   0.00($/GAL) 142000.0(BTU/GAL)       COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)       COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)       STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                          STORAGE FLUID DENSITY(LB/FT**3).........       62.09
HEAT LOAD CHARACTERISTICS                                 STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                                 STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                          COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                          STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
LINE LOSS COEFFICIENT (BTU/HR F FT**2)..       0.00       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........   10779.99       ESTIMATED GROUND REFLECTANCE............        0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00       ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00       ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DHW USERS (PEP)...............       5.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED STORAGE LOAD EFFECTIVENESS.          1.00       ESTIMATED HEX COST ($/FT**2) ...........        5.00
                                                          ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                          MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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S O L T A C - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR BRYCE CANYON UT

>>>>>DATA MATCH TO INPUT ID NO. 10233
JADD-1 LUK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	914.0	1412.0	19.5	0.1525E 08	0.2637E 07	1408.9	1.919	0.456
FEB	1236.0	1186.0	23.2	0.1281E 08	0.2382E 07	1829.9	1.555	0.546
MAR	1685.0	1114.0	29.1	0.1203E 08	0.2637E 07	2459.2	1.248	0.648
APR	2133.0	821.4	37.6	0.8871E 07	0.2552E 07	3055.9	0.974	0.746
MAY	2454.0	542.0	47.5	0.5354E 07	0.2637E 07	3553.9	0.814	0.876
JUN	2655.0	249.0	56.9	0.2689E 07	0.2552E 07	3750.1	0.749	1.000
JUL	2424.0	76.9	63.2	0.8305E 06	0.2637E 07	3660.5	0.782	1.000
AUG	2157.0	144.4	60.6	0.1560E 07	0.2637E 07	3287.7	0.903	1.000
SEP	1920.0	370.0	52.7	0.3996E 07	0.2552E 07	2699.9	1.143	1.000
OCT	1465.0	710.0	42.1	0.7663E 07	0.2637E 07	2038.8	1.500	0.849
NOV	1016.0	1060.0	29.6	0.1145E 08	0.2552E 07	1511.6	1.850	0.586
DEC	818.2	1358.6	21.2	0.1467E 08	0.2637E 07	1281.1	2.035	0.442
TOTAL		9044.5		0.9763E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.663

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	417.21
COLLECTOR TILT ANGLE (DEG) ....>>>	49.13
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0730
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0300
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1540
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.0824
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	20.4372
HEAT EXCHANGER LENGTH (FT)	121.14
////////////////////CONSTRAINTS////////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0740
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0070
COLLECTOR SIDE REYNOLDS NUMBER...........	0.760E 05
STORAGE SIDE REYNOLDS NUMBER	0.214E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0602
FLOW PARAMETER Z2(GEP/EPMIL).............	10.1471
FLOW PARAMETER Z1(GEP/E PUL).............	9.64

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.374E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.621E 05
COLLECTOR SIDE CONVECTION COEFF..........	1347.2422
STORAGE SIDE CONVECTION COEFFICIENT	3759.4312
COLLECTOR SIDE FLOW RATE (GPM)	7.6642
STORAGE SIDE FLOW RATE (GPM)	124.7847
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0184
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2991
HEAT EXCHANGER EFFECTIVENESS.............	0.9978
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.860E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.129E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6680
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.949E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	333.32
TOTAL INSTALLATION COST ($)	8743.49
COLLECTOR FLOW FACTOR(FPP)...............	0.9499

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*                          S O L O A D - 1                              *
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*      SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                     *
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*             DESIGN DATA OPTIONS/INPUTS SUMMARY                        *
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                   >>>>>DATA MATCH TO OUTPUT ID NO. 11111
                                   IMCD-1 LWK AUGUST 1979


LOCATION        DODGE CITY   KAN      COLLECTOR SOLARNETICS                      STUDY APPROACH          ANALYSIS
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LOCATION INDEX......           11     COLLECTOR TEST RESULTS,                    ECONOMIC ESTIMATES
LATITUDE,DEGREES....        37.77       SLOPE:                                   ------------------
MEAN TEMPERATURE....        54.31       PARAMETER,FRUL....         1.0380
INSOL(BTU/DAY FT**2)      1558.71       INTERCEPT:                               SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....      5284.10       PARAMETER,FRTA....         0.6910        DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....        55.00     BASE COST, $/FT**2...       12.98          INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                                  SELECTED PARAMETERS
----------------------------                                  -------------------

TYPE ENERGY BASE.........................       OIL    COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY    COST       HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL      0.70  0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE      0.99  0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS      0.70  0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                       STORAGE FLUID DENSITY(LB/FT**3).........         62.09
                                                       STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                              STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                              COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                       STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.25    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00    ESTIMATED GROUND REFLECTANCE...........,          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   30000.00    ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............       6.00    ESTIMATED HEX COST ($/FT**2) ...........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00    ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                       MAINTENANCE (% INSTALLED COST/YR).......          0.01
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*                  S O L O A D - 1                  *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*      RESULTS OF ANALYSIS FOR DODGE CITY   KAN     *
*                                                   *
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                 >>>>>DATA MATCH TO INPUT ID NO. 11111
                              JMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.3327E 08	0.2637E 07	1405.3	1.803	0.091
FEB	1122.0	875.3	34.0	0.2626E 08	0.2382E 07	1836.6	1.529	0.125
MAR	1477.0	739.2	41.2	0.2218E 08	0.2637E 07	2456.6	1.228	0.172
APR	1886.0	354.7	53.7	0.1064E 08	0.2552E 07	3094.4	1.002	0.318
MAY	2070.0	128.2	64.0	0.3846E 07	0.2637E 07	3553.5	0.868	0.562
JUN	2358.0	15.4	74.0	0.4620E 06	0.2552E 07	3750.3	0.812	0.934
JUL	2296.0	1.4	79.0	0.4200E 05	0.2637E 07	3660.4	0.837	0.996
AUG	2055.0	1.9	77.5	0.5700E 05	0.2637E 07	3286.7	0.945	0.997
SEP	1687.0	70.9	67.9	0.2127E 07	0.2552E 07	2697.6	1.141	0.738
OCT	1301.0	275.4	57.1	0.8262E 07	0.2637E 07	2035.7	1.438	0.383
NOV	893.6	701.0	41.7	0.2103E 08	0.2552E 07	1508.0	1.728	0.142
DEC	731.9	1011.7	32.4	0.3035E 08	0.2637E 07	1277.5	1.894	0.090
TOTAL		5284.1		0.1585E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.217

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	162.13	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.163E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	42.70	STORAGE SIDE CAPACITY (BTU/HR F).......	0.296E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0625	COLLECTOR SIDE CONVECTION COEFF.........	918.0244
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0724	STORAGE SIDE CONVECTION COEFFICIENT	3532.7219
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1217	COLLECTOR SIDE FLOW RATE (GPM)	3.3477
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.4313	STORAGE SIDE FLOW RATE (GPM)	59.3792
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.6000	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
HEAT EXCHANGER LENGTH (FT)	53.82	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3663
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS...........	0.8460
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0493	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.411E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0099	TOTAL ENERGY DEMAND (BTU/YEAR)	0.190E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.388E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2168
STORAGE SIDE REYNOLDS NUMBER	0.123E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.193E 04
CAPACITY RATIO (CMIN/CMAX).............	0.0552	HEX COEFFICIENT (BTU/HR F FT**2)........	298.11
FLOW PARAMETER Z2(GCP/FPUL)............	9.7027	TOTAL INSTALLATION COST ($)	4849.16
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.19	COLLECTOR FLOW FACTOR(FPP).............	0.9475

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*                          S O L D A D - 1                            *
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*        SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                 *
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*              DESIGN DATA OPTIONS/INPUTS SUMMARY                     *
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                  >>>>>DATA MATCH TO OUTPUT ID NO. 11112
                                   IMOD-1 LWK AUGUST 1979


LOCATION         DODGE CITY   KAN      COLLECTOR SOLARNETICS                    STUDY APPROACH         ANALYSIS
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LOCATION INDEX......          11       COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.77          SLOPE:                                ------------------
MEAN TEMPERATURE....       54.31          PARAMETER,FRUL....     1.0380
INSOL(BTU/DAY FT**2)     1558.71          INTERCEPT:                            SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....     5284.10          PARAMETER,FRTA....     0.6910         DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....       55.00       BASE COST,$/FT**2...      12.98          INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
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TYPE ENERGY BASE..............................  OIL   COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST      HEATING VALUE       COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL   0.70   0.90($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2   ELE   0.99   0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS   0.70   0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........        62.09
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.17    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00    ESTIMATED GROUND REFLECTANCE..........          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  20399.99    ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00    ESTIMATED CORRECTION FOR TAU ALFHA PRED.         0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............      6.00    ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS .     1.00    ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......         0.01
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S U L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>>>DATA MATCH TO INPUT ID NO. 11112
UMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.2262E 08	0.2637E 07	1405.3	1.791	0.123
FEB	1122.0	875.3	34.0	0.1786E 08	0.2382E 07	1836.6	1.523	0.169
MAR	1477.0	739.2	41.2	0.1508E 08	0.2637E 07	2456.6	1.229	0.229
APR	1886.0	354.7	53.7	0.7236E 07	0.2552E 07	3094.4	1.008	0.403
MAY	2070.0	128.2	64.0	0.2615E 07	0.2637E 07	3553.5	0.876	0.646
JUN	2358.0	15.4	74.0	0.3142E 06	0.2552E 07	3750.3	0.821	0.949
JUL	2296.0	1.4	79.0	0.2856E 05	0.2637E 07	3660.4	0.846	0.996
AUG	2055.0	1.9	77.5	0.3376E 05	0.2637E 07	3266.7	0.951	0.995
SEP	1687.0	70.9	67.9	0.1446E 07	0.2552E 07	2697.6	1.144	0.799
OCT	1301.0	275.4	57.1	0.5618E 07	0.2637E 07	2035.7	1.434	0.469
NOV	893.6	701.0	41.7	0.1430E 08	0.2552E 07	1508.0	1.718	0.189
DEC	731.9	1011.7	32.4	0.2064E 08	0.2637E 07	1277.5	1.880	0.121
TOTAL		5284.1		0.1078E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.281

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	155.19
COLLECTOR TILT ANGLE (DEG) ....>>>	41.55
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0599
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0679
STORAGE SIDE TUBE(HLX) INNER DIA. (FT)..	0.1272
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.5776
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.9825
HEAT EXCHANGER LENGTH (FT)	73.77
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0593
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0080
COLLECTOR SIDE REYNOLDS NUMBER..........	0.394E 05
STORAGE SIDE REYNOLDS NUMBER	0.159E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0412
FLOW PARAMETER Z2(GCP/FRUL).............	9.8035
FLOW PARAMETER Z1(GCP/FRPUL)............	9.29

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.159E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.385E 05
COLLECTOR SIDE CONVECTION COEFF.........	970.1899
STORAGE SIDE CONVECTION COEFFICIENT	3675.6736
COLLECTOR SIDE FLOW RATE (GPM)	3.2587
STORAGE SIDE FLOW RATE (GPM)	77.3898
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0209
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4955
HEAT EXCHANGER EFFECTIVENESS............	0.9246
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.390E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.139E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2811
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.174E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	304.15
TOTAL INSTALLATION COST ($)	4693.60
COLLECTOR FLOW FACTOR(FPP)..............	0.9481

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                  *              S O L O A D - I                       *
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                  *    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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                  *         DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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                                   >>>>>DATA MATCH TO OUTPUT ID NO. 11113
                                                 IMOD-I LWK AUGUST 1979


LOCATION       DODGE CITY   KAN     COLLECTOR SOLARNETICS                    STUDY APPROACH          ANALYSIS
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LOCATION INDEX......        11      COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.77        SLOPE:                                 ------------------
MEAN TEMPERATURE....     54.31        PARAMETER,FRUL....     1.0380
INSOL(BTU/DAY FT**2)   1558.71        INTERCEPT:                             SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,FDC.....   5284.10        PARAMETER,FRTA....     0.6910          DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00      BASE COST,$/FT**2...      12.98          INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                             SELECTED PARAMETERS
----------------------------                             -------------------

TYPE ENERGY BASE..........................       OIL     COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1    OIL    0.70   0.90($/GAL )  142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2    ELE    0.99   0.05($/KWH)     3413.0(BTU/KWH)     COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS    0.70   0.40($/THM)   100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........       104.00
                                                         STORAGE FLUID DENSITY(LB/FT**3).........        62.05
HEAT LOAD CHARACTERISTICS                                STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
-------------------------                                STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
                                                         COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                         STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00     ESTIMATED GROUND REFLECTANCE...........          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99     ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00     ESTIMATED CORRECTION FOR TAU ALPHA PROD.         0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............        6.00     ESTIMATED HEX COST ($/FT**2) ..........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00     ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                         MAINTENANCE (% INSTALLED COST/YR).......         0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

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\>\>\>\>\>DATA MATCH TO INPUT ID NO. 11113
OMOC-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.1198E 08	0.2637E 07	1405.3	1.778	0.160
FEB	1122.0	875.3	34.0	0.9453E 07	0.2382E 07	1836.6	1.516	0.217
MAR	1477.0	739.2	41.2	0.7983E 07	0.2637E 07	2456.6	1.229	0.288
APR	1886.0	354.7	53.7	0.3831E 07	0.2552E 07	3094.4	1.013	0.466
MAY	2070.0	128.2	64.0	0.1385E 07	0.2637E 07	3553.5	0.885	0.656
JUN	2358.0	15.4	74.0	0.1663E 06	0.2552E 07	3750.3	0.831	0.875
JUL	2296.0	1.4	79.0	0.1512E 05	0.2637E 07	3660.4	0.855	0.909
AUG	2055.0	1.9	77.5	0.2052E 05	0.2637E 07	3286.7	0.958	0.908
SEP	1687.0	70.9	67.9	0.7657E 06	0.2552E 07	2697.6	1.146	0.768
OCT	1301.0	275.4	57.1	0.2974E 07	0.2637E 07	2035.7	1.430	0.517
NOV	893.6	701.0	41.7	0.7571E 07	0.2552E 07	1508.0	1.706	0.235
DEC	731.9	1011.7	32.4	0.1093E 08	0.2637E 07	1277.5	1.865	0.156
TOTAL		5284.1		0.5707E 08	0.3105E 08			
						\>\>WEIGHTED AVERAGE		0.349

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....\>\>\>	121.97
COLLECTOR TILT ANGLE (DEG) ....\>\>\>	40.34
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0491
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0541
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1120
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.9489
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.0047
HEAT EXCHANGER LENGTH (FT)	49.79
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0580
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.369E 05
STORAGE SIDE REYNOLDS NUMBER	0.131E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0451
FLOW PARAMETER Z2(GCP/FRUL)............	9.6419
FLOW PARAMETER Z1(GCP/FRPUL)............	9.13

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.122E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.271E 05
COLLECTOR SIDE CONVECTION COEFF..........	1124.3823
STORAGE SIDE CONVECTION COEFFICIENT	3251.7253
COLLECTOR SIDE FLOW RATE (GPM)	2.5028
STORAGE SIDE FLOW RATE (GPM)	54.3385
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4455
HEAT EXCHANGER EFFECTIVENESS............	0.8545
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.307E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.881E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3489
OBJECTIVE: NPV OF SOLAR INVESTMENT ..\>\>\>	0.143E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	314.54
TOTAL INSTALLATION COST ($)	3646.53
COLLECTOR FLOW FACTOR(FPP)...............	0.9472

S O L T A B - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

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>>>>>DATA MATCH TO OUTPUT ID NO. 11221
[illegible] AUGUST 1979

LOCATION	DODGE CITY KAN	COLLECTOR AMERICAN SUN		STUDY APPROACH	ANALYSIS
LOCATION INDEX......	11	COLLECTOR TEST RESULTS,		ECONOMIC ESTIMATES	
LATITUDE,DEGREES....	37.77	SLOPE:			
MEAN TEMPERATURE....	54.31	PARAMETER,FR UL....	1.0390		
INSOL(BTU/DAY FT**2)	1558.71	INTERCEPT:		SYSTEM LIFE(YEARS)..	20.00
LOAL FACTOR,FDD.....	5284.10	PARAMETER,FR TA....	0.6380	DISCOUNT RATE	0.0900
MEAN GROUND TEMP....	55.00	BASE COST,$/FT**2...	6.55	INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE......................... OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	1.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.25
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	30000.00
DOMESTIC HOT WATER (DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USAGE (GAL/PERS) ...	20.00
ESTIMATED DHW USERS (PERS)...............	6.00
ESTIMATED STORAGE [illegible] EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.31
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.05
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA EFFD.	0.95
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>>>DATA MATCH TO INPUT ID NO. 11221
DMCO-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.3327E 08	0.2637E 07	1405.3	1.670	0.277
FEB	1122.0	875.3	34.0	0.2626E 08	0.2382E 07	1836.6	1.555	0.363
MAR	1477.0	739.2	41.2	0.2218E 08	0.2637E 07	2456.6	1.211	0.462
APR	1886.0	354.7	53.7	0.1064E 08	0.2552E 07	3094.4	0.954	0.722
MAY	2070.0	128.2	64.0	0.3846E 07	0.2637E 07	3553.5	0.805	0.941
JUN	2358.0	15.4	74.0	0.4620E 06	0.2552E 07	3750.3	0.742	1.000
JUL	2296.0	1.4	79.0	0.4200E 05	0.2637E 07	3660.4	0.769	1.000
AUG	2055.0	1.7	77.5	0.5700E 05	0.2637E 07	3286.7	0.889	1.000
SEP	1687.0	70.9	67.5	0.2127E 07	0.2552E 07	2697.6	1.111	1.000
OCT	1301.0	275.4	57.1	0.3262E 07	0.2637E 07	2035.7	1.451	0.849
NOV	893.7	701.0	41.7	0.2103E 08	0.2552E 07	1508.0	1.784	0.411
DEC	731.9	1011.7	32.4	0.3035E 08	0.2637E 07	1277.5	1.975	0.275
TOTAL		5284.1		0.1585E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.467

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	575.06
COLLECTOR TILT ANGLE (DEG) ....>>>	50.96
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0347
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0397
STORAGE SIDE TUBE(HEX) INLET DIA. (FT)..	0.1679
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.7248
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	21.3183
HEAT EXCHANGER LENGTH (FT)	114.51
///////////////////CONSTRAINTS///////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0662
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER	0.900E 05
STORAGE SIDE REYNOLDS NUMBER	0.205E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0841
FLOW PARAMETER Z2(GPM/FT HL)...............	9.6676
FLOW PARAMETER Z1(GPM/FRPUL)...............	7.10

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.574E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.683E 05
COLLECTOR SIDE CONVECTION COEFF..........	1188.4792
STORAGE SIDE CONVECTION COEFFICIENT	3995.0862
COLLECTOR SIDE FLOW RATE (GPM)	11.7686
STORAGE SIDE FLOW RATE (GPM)	137.0885
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2384
HEAT EXCHANGER EFFECTIVENESS..............	0.8393
SOLAR ENERGY DELIVERED (BTU/YEAR)........	0.835E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.190E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4669
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.316E 04
HEX COEFFICIENT (BTU/HR F FT**2).........	322.96
TOTAL INSTALLATION COST ($)	10391.44
COLLECTOR FLOW FACTOR(FPP)...............	0.9470

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*                          S O L I A C - 1                            *
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*       SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                  *
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*                DESIGN DATA OPTIONS/INPUTS SUMMARY                   *
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                      >>>>>DATA MATCH TO OUTPUT ID NO. 11222
                                     IMOD-1 LWK AUGUST 1979


LOCATION        DODGE CITY   KAN     COLLECTOR AMERICAN SUN                   STUDY APPROACH          ANALYSIS
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LOCATION INDEX......         11      COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.77        SLOPE:                                 ------------------
MEAN TEMPERATURE....      54.31        PARAMETER,FRUL....     1.0390
INSOL(BTU/DAY FT**2)    1558.71        INTERCEPT:                             SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....    5284.10        PARAMETER,FRTA....     0.6380          DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....      55.00      BASE COST,$/FT**2...       6.55          INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS
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TYPE ENERGY BASE..............................       OIL   COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)        COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)        COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)        STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                           STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                           STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                                  STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                                  COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                           STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                           HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00       ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99       ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00       ESTIMATED CORRECTION FOR TAU ALPHA PROD.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............        6.00       ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00       ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                           MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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S O L I A C - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>>>DATA MATCH TO INPUT ID NO. 11222
IMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.2262E 08	0.2637E 07	1405.3	1.866	0.281
FEB	1122.0	875.3	34.0	0.1786E 08	0.2382E 07	1836.6	1.554	0.367
MAR	1477.0	759.2	41.2	0.1508E 08	0.2637E 07	2456.6	1.213	0.464
APR	1886.0	354.7	53.7	0.7236E 07	0.2552E 07	3094.4	0.958	0.709
MAY	2070.0	128.2	64.0	0.2615E 07	0.2637E 07	3553.5	0.809	0.916
JUN	2358.0	15.4	74.0	0.3142E 06	0.2552E 07	3750.3	0.747	1.000
JUL	2296.0	1.4	79.0	0.2856E 05	0.2637E 07	3660.4	0.774	1.000
AUG	2055.0	1.9	77.5	0.3876E 05	0.2637E 07	3286.7	0.893	1.000
SEP	1687.0	70.9	67.9	0.1446E 07	0.2552E 07	2697.6	1.114	1.000
OCT	1301.0	275.4	57.1	0.5618E 07	0.2637E 07	2035.7	1.451	0.827
NOV	893.6	701.0	41.7	0.1430E 08	0.2552E 07	1508.0	1.781	0.410
DEC	731.9	1011.7	32.4	0.2064E 08	0.2637E 07	1277.5	1.971	0.277
TOTAL		5284.1		0.1078E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.482

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	416.70
COLLECTOR TILT ANGLE (DEG) ....>>>	50.40
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0757
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0807
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1424
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	4.2221
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.9100
HEAT EXCHANGER LENGTH (FT)	78.09
////////////////////CONSTRAINTS////////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0616
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER.............	0.815E 05
STORAGE SIDE REYNOLDS NUMBER	0.165E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0911
FLOW PARAMETER Z2(GCP/FRUL)...............	9.6103
FLOW PARAMETER Z1(GCP/FPUL)...............	9.10

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.416E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.456E 05
COLLECTOR SIDE CONVECTION COEFF...........	1373.8562
STORAGE SIDE CONVECTION COEFFICIENT	3614.0764
COLLECTOR SIDE FLOW RATE (GPM)	8.5305
STORAGE SIDE FLOW RATE (GPM)	91.6591
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2200
HEAT EXCHANGER EFFECTIVENESS.............	0.7594
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.669E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.139E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4817
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.655E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	333.51
TOTAL INSTALLATION COST ($)	7495.21
COLLECTOR FLOW FACTOR(FFP)...............	0.9470

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                    *                  S O L O A D - 1                  *
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                    *   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
                    *   ---          -            -           -         *
                    *          DESIGN DATA OPTIONS/INPUTS SUMMARY       *
                    *                                                   *
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                                    >>>>>DATA MATCH TO OUTPUT ID NO. 11223
                                                 IMOD-1 LWK AUGUST 1979

LOCATION      DODGE CITY   KAN    COLLECTOR AMERICAN SUN                  STUDY APPROACH          ANALYSIS
--------                          ---------                               --------------

LOCATION INDEX......          11  COLLECTOR TEST RESULTS,                 ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.77     SLOPE:                               ------------------
MEAN TEMPERATURE....       54.31     PARAMETER,FRUL....      1.0390
INSOL(BTU/DAY FT**2)     1558.71     INTERCEPT:                           SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....     5284.10     PARAMETER,FRTA....      0.6380       DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00  BASE COST,$/FT**2...         6.55       INFLATION RATE......       0.1100


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
----------------------------                          -------------------

TYPE ENERGY BASE.........................       OIL   COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1   OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3   GAS     0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........       62.05
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.09   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00   ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   10799.99   ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............       6.00   ESTIMATED HEX COST ($/FT**2) ..........         5.00
ESTIMATED STORAGE FLUID EFFECTIVENESS.         1.00   ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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S O L U A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>>>DATA MATCH TO INPUT ID NO. 11223
JMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.1193E 08	0.2637E 07	1405.3	1.860	0.322
FEB	1122.0	875.3	34.0	0.9453E 07	0.2382E 07	1836.6	1.552	0.415
MAR	1477.0	739.2	41.2	0.7983E 07	0.2637E 07	2456.6	1.215	0.514
APR	1886.0	354.7	53.7	0.3831E 07	0.2552E 07	3094.4	0.964	0.733
MAY	2070.0	128.2	64.0	0.1385E 07	0.2637E 07	3553.5	0.817	0.890
JUN	2358.0	15.4	74.0	0.1663E 06	0.2552E 07	3750.3	0.756	1.000
JUL	2296.0	1.4	79.0	0.1512E 05	0.2637E 07	3660.4	0.783	1.000
AUG	2055.0	1.9	77.5	0.2052E 05	0.2637E 07	3286.7	0.900	1.000
SEP	1687.0	70.9	67.9	0.7657E 06	0.2552E 07	2697.6	1.118	0.993
OCT	1301.0	275.4	57.1	0.2974E 07	0.2637E 07	2035.7	1.450	0.829
NOV	893.6	701.0	41.7	0.7571E 07	0.2552E 07	1508.0	1.776	0.452
DEC	731.9	1011.7	32.4	0.1093E 08	0.2637E 07	1277.5	1.963	0.316
TOTAL		5284.1		0.5707E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.547

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	280.51
COLLECTOR TILT ANGLE (DEG) ....>>>	49.42
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0728
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0778
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1371
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1325
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.5024
HEAT EXCHANGER LENGTH (FT)	78.32
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0594
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.581E 05
STORAGE SIDE REYNOLDS NUMBER	0.155E 06
CAPACITY RATIO (CMIN/CMAX)............	0.0688
FLOW PARAMETER Z2(GPM/FPHL)............	9.78+1
FLOW PARAMETER Z1(GCF/FRPHL)...........	9.28

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.285E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.414E 05
COLLECTOR SIDE CONVECTION COEFF.........	1090.6305
STORAGE SIDE CONVECTION COEFFICIENT	3574.9036
COLLECTOR SIDE FLOW RATE (GPM)	5.8465
STORAGE SIDE FLOW RATE (GPM)	83.1904
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2966
HEAT EXCHANGER EFFECTIVENESS............	0.8494
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.482E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.881E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.5467
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.508E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	313.52
TOTAL INSTALLATION COST ($)	5075.35
COLLECTOR FLOW FACTOR(FPP)..............	0.9480

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*                    S I L O A D - 1                       *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN           *
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*          DESIGN DATA OPTIONS/INPUTS SUMMARY              *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 11232
                                 IMJD-1 LWK AUGUST 1979


LOCATION        DODGE CITY   KAN    COLLECTOR FEDERAL PRISM I. D         STUDY APPROACH          ANALYSIS
--------                            ---------                            --------------

LOCATION INDEX......         11     COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      37.77       SLOPE:                             ------------------
MEAN TEMPERATURE....      54.31        PARAMETER,FRUL....     0.8830
INSOL(BTU/DAY FT**2)    1558.71        INTERCEPT:                        SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....    5284.10        PARAMETER,FRTA....     0.6270     DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...        9.40     INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS
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TYPE ENERGY BASE............................            OIL  COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1   OIL      0.70    0.90($/GAL) 142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE      0.99    0.05($/KWH)   3413.0(BTU/KWH)         COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3   GAS      0.70    0.40($/THM) 100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                                    COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.17       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00       ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........      20399.99       ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00       ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...          20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............          6.00       ESTIMATED HEX COST ($/FT**2) ..........        5.00
ESTIMATED STORAGE FLUID EFFECTIVENESS.            1.00       ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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S O L A C - I

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR DODGE CITY KAN

>>>>>DATA MATCH TO INPUT ID NO. 11232
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	827.0	1109.0	29.2	0.2262E 08	0.2637E 07	1405.3	1.861	0.258
FEB	1122.0	875.3	34.0	0.1736E 08	0.2382E 07	1836.6	1.553	0.336
MAR	1477.0	739.2	41.2	0.1508E 08	0.2637E 07	2456.6	1.215	0.429
APR	1886.0	354.7	53.7	0.7236E 07	0.2552E 07	3094.4	0.962	0.673
MAY	2070.0	128.2	64.0	0.2615E 07	0.2637E 07	3553.5	0.815	0.914
JUN	2358.0	15.4	74.0	0.3142E 06	0.2552E 07	3750.3	0.753	1.000
JUL	2256.0	1.4	79.0	0.2858E 05	0.2637E 07	3660.4	0.780	1.000
AUG	2055.0	1.9	77.5	0.3876E 05	0.2637E 07	3286.7	0.898	1.000
SEP	1687.0	70.9	67.9	0.1446E 07	0.2552E 07	2697.6	1.117	1.000
OCT	1301.0	275.4	57.1	0.5613E 07	0.2637E 07	2035.7	1.450	0.793
NOV	893.6	701.0	41.7	0.1430E 08	0.2552E 07	1508.0	1.777	0.379
DEC	731.9	1011.7	32.4	0.2064E 08	0.2637E 07	1277.5	1.965	0.256
TOTAL		5284.1		0.1078E 09	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.457

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	360.70
COLLECTOR TILT ANGLE (DEG) ....>>>	49.71
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0732
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0782
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1329
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3052
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.1044
HEAT EXCHANGER LENGTH (FT)	63.16
////////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0547
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.613E 05
STORAGE SIDE REYNOLDS NUMBER	0.140E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0831
FLOW PARAMETER Z2(UP/FRUL).............	9.5707
FLOW PARAMETER Z1(GCP/FRPUL)............	9.06

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.305E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.367E 05
COLLECTOR SIDE CONVECTION COEFF.........	1137.0083
STORAGE SIDE CONVECTION COEFFICIENT	3551.4089
COLLECTOR SIDE FLOW RATE (GPM)	6.2496
STORAGE SIDE FLOW RATE (GPM)	73.6801
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0173
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2043
HEAT EXCHANGER EFFECTIVENESS...........	0.7656
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.634E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.139E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4567
OBJECTIVE : NPV OF SOLAR INVESTMENT ..>>>	0.584E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	317.05
TOTAL INSTALLATION COST ($)	7511.69
COLLECTOR FLOW FACTOR(FPP)..............	0.9468

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*               S O L D A D - 1                 *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
*                                               *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY     *
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                >>>>>DATA MATCH TO OUTPUT ID NO. 12111
                               IMOD-1 LWK AUGUST 1979


LOCATION      RICHMOND        VA    COLLECTOR SOLARNETICS                 STUDY APPROACH        ANALYSIS
--------                            ---------                             --------------

LOCATION INDEX......          12    COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.50      SLOPE:                              ------------------
MEAN TEMPERATURE....       57.26      PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)     1247.82      INTERCEPT:                          SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....     4071.20      PARAMETER,FRTA....      0.6910      DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....       55.00    BASE COST,$/FT**2...       12.98      INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
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TYPE ENERGY BASE............................    OIL   COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1   OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3   GAS     0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3).........       62.09
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                      COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.25   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00   ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   30000.00   ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............       6.00   ESTIMATED HEX COST ($/FT**2) ..........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00   ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......        0.01
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S C L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12111
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.9	0.2609E 08	0.2637E 07	1419.3	1.570	0.039
FEB	876.0	722.9	39.4	0.2169E 08	0.2382E 07	1849.5	1.390	0.059
MAR	1210.2	572.7	46.6	0.1718E 08	0.2637E 07	2466.7	1.186	0.102
APR	1566.0	255.9	57.7	0.7677E 07	0.2552E 07	3100.2	1.021	0.216
MAY	1762.0	76.3	65.8	0.2289E 07	0.2637E 07	3554.9	0.918	0.432
JUN	1872.4	7.6	73.3	0.2280E 06	0.2552E 07	3749.4	0.877	0.665
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.897	0.688
AUG	1600.6	0.6	75.5	0.1800E 05	0.2637E 07	3290.7	0.975	0.671
SEP	1347.9	36.4	69.0	0.1092E 07	0.2552E 07	2706.3	1.120	0.498
OCT	1032.7	241.2	58.0	0.7236E 07	0.2637E 07	2047.8	1.332	0.190
NOV	733.0	500.6	48.4	0.1502E 08	0.2552E 07	1521.8	1.549	0.080
DEC	566.8	787.4	39.6	0.2362E 08	0.2637E 07	1291.6	1.637	0.038
TOTAL		4071.2		0.1221E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.133

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.987E 03
COLLECTOR TILT ANGLE (DEG) ....>>>	34.76	STORAGE SIDE CAPACITY (BTU/HR F).......	0.371E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0487	COLLECTOR SIDE CONVECTION COEFF.........	960.0593
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0587	STORAGE SIDE CONVECTION COEFFICIENT	3654.1084
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1212	COLLECTOR SIDE FLOW RATE (GPM)	2.0237
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.4164	STORAGE SIDE FLOW RATE (GPM)	74.4714
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.7066	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
HEAT EXCHANGER LENGTH (FT)	58.82	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.7447
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9345
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0625	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.204E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.153E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.300E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1335
STORAGE SIDE REYNOLDS NUMBER	0.166E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.367E 03
CAPACITY RATIO (CMIN/CMAX)..............	0.0266	HEX COEFFICIENT (BTU/HR F FT**2)........	304.01
FLOW PARAMETER Z2(GCP/FRUL).............	9.5092	TOTAL INSTALLATION COST ($)	3005.69
FLOW PARAMETER Z1(GCP/FRPUL)............	9.00	COLLECTOR FLOW FACTOR(FPP)..............	0.9464

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*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                *
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*              DESIGN DATA OPTIONS/INPUTS SUMMARY                *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 12112
                                  IMCD-1 LJK AUGUST 1979


LOCATION      RICHMOND      VA     COLLECTOR SOLARNETICS                      STUDY APPROACH          ANALYSIS
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LOCATION INDEX......        12     COLLECTOR TEST RESULTS,                    ECONOMIC ESTIMATES
LATITUDE,DEGREES....     37.50       SLOPE:                                   ------------------
MEAN TEMPERATURE....     57.26       PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)   1247.82       INTERCEPT:                               SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....   4071.20       PARAMETER,FRTA....      0.6910           DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00     BASE COST,$/FT**2...     12.98             INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                             SELECTED PARAMETERS
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TYPE ENERGY BASI..........................        OIL   COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......       60.91
  1   OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2   ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3   GAS     0.70    1.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........       62.09
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
-------------------------                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                        COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.17      ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00      ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY).......   20399.99      ESTIMATED PUMPING POWER(KWH/AREAC).....      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00      ESTIMATED CORRECTION FOR TAU ALPHA PROD.        0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...      20.00      ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)..............       0.00      ESTIMATED HEX COST ($/FT**2) ..........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00      ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......        0.01
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*               S O L O A D - 1                      *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN     *
*   ---          -            -         -            *
*     RESULTS OF ANALYSIS FOR RICHMOND        VA     *
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                    >>>>>DATA MATCH TO INPUT ID NO. 12112
                                 IMOD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.9	0.1774E 08	0.2637E 07	1419.3	1.579	0.055
FEB	876.0	722.9	39.4	0.1475E 08	0.2382E 07	1849.5	1.395	0.083
MAR	1210.2	572.7	46.6	0.1168E 08	0.2637E 07	2466.7	1.187	0.138
APR	1566.0	255.9	57.7	0.5220E 07	0.2552E 07	3100.2	1.016	0.276
MAY	1762.0	76.3	65.8	0.1557E 07	0.2637E 07	3554.9	0.914	0.488
JUN	1872.4	7.6	73.3	0.1550E 06	0.2552E 07	3749.4	0.872	0.673
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.891	0.684
AUG	1600.6	0.6	75.5	0.1224E 05	0.2637E 07	3290.7	0.971	0.669
SEP	1347.9	36.4	69.0	0.7426E 06	0.2552E 07	2706.3	1.119	0.537
OCT	1032.7	241.2	58.0	0.4920E 07	0.2637E 07	2047.8	1.335	0.243
NOV	733.0	500.6	48.4	0.1021E 08	0.2552E 07	1521.8	1.558	0.109
DEC	566.8	787.4	39.6	0.1606E 08	0.2637E 07	1291.6	1.648	0.054
TOTAL		4071.2		0.8305E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.176

DESIGN VARIABLES/CONSTRAINTS	
COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	35.63
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0455
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0555
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1191
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.7354
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.9660
HEAT EXCHANGER LENGTH (FT)	60.70
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0636
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.323E 05
STORAGE SIDE REYNOLDS NUMBER	0.161E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0283
FLOW PARAMETER Z2(GCP/FRUL).............	9.5591
FLOW PARAMETER Z1(GCP/FRPUL)............	3.05

OTHER PARAMETERS	
COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.992E 03
STORAGE SIDE CAPACITY (BTU/HR F)........	0.350E 05
COLLECTOR SIDE CONVECTION COEFF.........	1090.5000
STORAGE SIDE CONVECTION COEFFICIENT	3528.3804
COLLECTOR SIDE FLOW RATE (GPM)	2.0343
STORAGE SIDE FLOW RATE (GPM)	70.3113
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.7031
HEAT EXCHANGER EFFECTIVENESS............	0.9333
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.201E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1764
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.316E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	315.47
TOTAL INSTALLATION COST ($)	5003.76
COLLECTOR FLOW FACTOR(FPP)..............	0.9467

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*                       S O L I A C - 1                            *
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*          SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN            *
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*                  DESIGN DATA OPTIONS/INPUTS SUMMARY              *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 12113
                                  IMOD-1 LWK AUGUST 1979


LOCATION       RICHMOND        VA     COLLECTOR SOLARNETICS                        STUDY APPROACH          ANALYSIS
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LOCATION INDEX......           12     COLLECTOR TEST RESULTS,                      ECONOMIC ESTIMATES
LATITUDE,DEGREES....        37.50        SLOPE:                                    ------------------
MEAN TEMPERATURE....        57.26        PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)      1247.82        INTERCEPT:                                SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HLC.....      4071.20        PARAMETER,FRTA....      0.6910            DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....        55.00     BASE COST,$/FT**2...      12.98              INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                           SELECTED PARAMETERS
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TYPE ENERGY BASE.........................         OIL  COLLECTOR FLUID MEAN TEMPERATURE........      176.00
INDEX TYPE EFFICIENCY    COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                       STORAGE FLUID DENSITY(LB/FT**3).........       62.09
                                                       STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                              STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                              COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                       STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00   ESTIMATED GROUND REFLECTANCE...........,        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99   ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00   ESTIMATED CORRECTION FOR TAU ALPHA PROD.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............        6.00   ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00   ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                       MAINTENANCE (% INSTALLED COST/YR).......        0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12113
JMOD-I LWK AUGUST 1975

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.5	0.9392E 07	0.2637E 07	1419.3	1.577	0.092
FEB	876.0	722.9	39.4	0.7307E 07	0.2382E 07	1849.5	1.395	0.136
MAR	1210.2	572.7	46.6	0.6185E 07	0.2637E 07	2466.7	1.186	0.217
APR	1566.0	255.9	57.7	0.2764E 07	0.2552E 07	3100.2	1.018	0.383
MAY	1762.0	76.3	65.8	0.8240E 06	0.2637E 07	3554.9	0.914	0.565
JUN	1872.4	7.6	73.3	0.8208E 05	0.2552E 07	3749.4	0.873	0.686
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.892	0.685
AUG	1600.6	0.6	75.5	0.6480E 04	0.2637E 07	3290.7	0.972	0.671
SEP	1347.9	36.4	69.0	0.3931E 06	0.2552E 07	2706.3	1.119	0.583
OCT	1032.7	241.2	58.0	0.2605E 07	0.2637E 07	2047.8	1.335	0.335
NOV	733.0	500.6	48.4	0.5406E 07	0.2552E 07	1521.8	1.556	0.169
DEC	566.8	787.4	39.6	0.8504E 07	0.2637E 07	1291.6	1.646	0.089
TOTAL		4071.2		0.4397E 08	0.3105E 08			
						>>>WEIGHTED	AVERAGE	0.261

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	35.48
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0385
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0485
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1353
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.8840
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	24.7299
HEAT EXCHANGER LENGTH (FT)	66.83
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0868
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.382E 05
STORAGE SIDE REYNOLDS NUMBER	0.303E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0143
FLOW PARAMETER Z2(GCF/FRUL).............	9.5307
FLOW PARAMETER Z1(GCP/FRPUL)............	9.03

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.990E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.692E 05
COLLECTOR SIDE CONVECTION COEFF.........	1471.1946
STORAGE SIDE CONVECTION COEFFICIENT	4486.1680
COLLECTOR SIDE FLOW RATE (GPM)	2.0302
STORAGE SIDE FLOW RATE (GPM)	138.9749
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.3897
HEAT EXCHANGER EFFECTIVENESS............	0.9398
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.196E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.750E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2612
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.232E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	347.60
TOTAL INSTALLATION COST ($)	3000.24
COLLECTOR FLOW FACTOR(FPP)..............	0.9466

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                         S O L I A D - 1
          SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN
               DESIGN DATA OPTIONS/INPUTS SUMMARY
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 12221
                               IMOD-1 EWR AUGUST 1979

LOCATION      RICHMOND        VA     COLLECTOR AMERICAN SUN                  STUDY APPROACH        ANALYSIS

LOCATION INDEX.......           12   COLLECTOR TEST RESULTS,                 ECONOMIC ESTIMATES
LATITUDE,DEGREES....         37.50     SLOPE:
MEAN TEMPERATURE....         57.26     PARAMETER,FRUL....      1.0390
INSOL(BTU/DAY FT**2)       1247.82     INTERCEPT:                            SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,UDD.....       4071.20     PARAMETER,FRTA....      0.6380        DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....         55.00   BASE COST,$/FT**2...         6.55       INFLATION RATE......     0.1100

ENERGY COMPARATIVE ESTIMATES                                      SELECTED PARAMETERS

TYPE ENERGY BASE.............................OIL               COLLECTOR FLUID MEAN TEMPERATURE.........      176.00
INDEX TYPE EFFICIENCY   COST           HEATING VALUE           COLLECTOR FLUID DENSITY(LB/FT**3).......       60.91
  1    OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)           COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)           COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS     0.70   0.40($/THM)  100000.0(BTU/THM)           STORAGE FLUID MEAN TEMPERATURE .........      104.00
                                                               STORAGE FLUID DENSITY(LB/FT**3).........       62.09
HEAT LOAD CHARACTERISTICS                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
                                                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
                                                               COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                               STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.25         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........      30000.00         ESTIMATED GROUND REFLECTANCE............        0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00         ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
ESTIMATED DAILY DHW USE OF (GAL/PER) ...         20.00         ESTIMATED CORRECTION FOR TAU ALPHA PROD.        0.93
ESTIMATED OCCUPANTS (PEOP)..............          6.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.          1.00         ESTIMATED HEX COST ($/FT**2) ...........        5.00
                                                               ESTIMATED STORAGE TANK COST($/LB STORED)        0.03
                                                               MAINTENANCE (% INSTALLED COST/YR).......      0.0010
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S O L C A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12221
JMCD-I LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.5	869.6	36.9	0.2609E 08	0.2637E 07	1419.3	1.640	0.107
FEB	876.0	722.9	39.4	0.2169E 08	0.2382E 07	1849.5	1.427	0.157
MAR	1210.2	572.7	46.6	0.1718E 08	0.2637E 07	2466.7	1.184	0.254
APR	1566.0	255.9	57.7	0.7677E 07	0.2552E 07	3100.2	0.969	0.483
MAY	1752.0	75.3	65.8	0.2289E 07	0.2637E 07	3554.9	0.870	0.791
JUN	1872.1	7.6	73.3	0.2280E 06	0.2552E 07	3749.4	0.823	0.955
JUL	1771.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.845	0.963
AUG	1600.0	0.6	75.5	0.1800E 05	0.2637E 07	3290.7	0.936	0.959
SEP	1347.5	36.4	69.0	0.1092E 07	0.2552E 07	2706.3	1.105	0.879
OCT	1032.7	241.2	58.0	0.7236E 07	0.2637E 07	2047.8	1.356	0.454
NOV	733.0	500.6	48.4	0.1502E 08	0.2552E 07	1521.8	1.615	0.211
DEC	566.8	787.4	39.6	0.2362E 08	0.2637E 07	1291.6	1.720	0.106
TOTAL		4071.2		0.1221E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.278

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	305.53
COLLECTOR TILT ANGLE (DEG) ....>>>	42.52
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0723
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0773
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1395
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.3592
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.2508
HEAT EXCHANGER LENGTH (FT)	50.49
///////////////////CONSTRAINTS///////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0617
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER	0.423E 05
STORAGE SIDE REYNOLDS NUMBER	0.166E 06
CAPACITY RATIO (CMIN/CMAX)................	0.0678
FLOW PARAMETER Z2(GPM/FT)...............	9.0755
FLOW PARAMETER Z1(GPM/FPPH)...............	0.17

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.307E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.453E 05
COLLECTOR SIDE CONVECTION COEFF...........	1155.9226
STORAGE SIDE CONVECTION COEFFICIENT	3472.9561
COLLECTOR SIDE FLOW RATE (GPM)	6.2971
STORAGE SIDE FLOW RATE (GPM)	90.9582
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2978
HEAT EXCHANGER EFFECTIVENESS.............	0.8418
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.425E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.153E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2780
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.336E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	319.40
TOTAL INSTALLATION COST ($)	5592.50
COLLECTOR FLOW FACTOR(FPP)..............	0.9474

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*                        S O L O A D - 1                              *
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*     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN                    *
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*              DESIGN DATA OPTIONS/INPUTS SUMMARY                     *
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                        >>>>>DATA MATCH TO OUTPUT ID NO. 12222
                                       MOD-1 LWK AUGUST 1979


LOCATION        RICHMOND        VA      COLLECTOR AMERICAN SUN                      STUDY APPROACH         ANALYSIS
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LOCATION INDEX.......           12      COLLECTOR TEST RESULTS,                     ECONOMIC ESTIMATES
LATITUDE,DEGREES.....        37.50         SLOPE:                                   ------------------
MEAN TEMPERATURE.....        57.20         PARAMETER,FRUL....       1.0350
INSOL(BTU/DAY FT**2)       1247.82         INTERCEPT:                               SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,EDD......      4071.20         PARAMETER,FRTA....       0.6380          DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP.....        55.00      BASE COST,$/FT**2...          6.55          INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                                 SELECTED PARAMETERS
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TYPE ENERGY BASE.........................            OIL     COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY     COST         HEATING VALUE         COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)         COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3    GAS     0.70    0.40($/THM) 100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE .........     104.00
                                                             STORAGE FLUID DENSITY(LB/FT**3).........      62.09
                                                             STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
HEAT LOAD CHARACTERISTICS                                    STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
-------------------------                                    COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                             STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                             HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00         ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99         ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00         ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...        20.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............        6.00         ESTIMATED HEX COST ($/FT**2) ...........       5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00         ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                             MAINTENANCE (% INSTALLED COST/YR).......     0.0010
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S I L T A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12222
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.9	0.1774E 08	0.2637E 07	1419.3	1.636	0.126
FEB	876.0	722.9	39.4	0.1475E 08	0.2382E 07	1849.5	1.425	0.184
MAR	1210.2	572.7	46.6	0.1168E 08	0.2637E 07	2466.7	1.185	0.292
APR	1566.0	255.9	57.7	0.5220E 07	0.2552E 07	3100.2	0.991	0.526
MAY	1762.0	76.3	65.8	0.1557E 07	0.2637E 07	3554.9	0.874	0.793
JUN	1872.4	7.6	73.3	0.1550E 06	0.2552E 07	3749.4	0.827	0.933
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.849	0.939
AUG	1600.6	0.6	75.5	0.1224E 05	0.2637E 07	3290.7	0.939	0.934
SEP	1347.9	36.4	69.0	0.7426E 06	0.2552E 07	2706.3	1.107	0.851
OCT	1032.7	241.2	58.0	0.4920E 07	0.2637E 07	2047.8	1.355	0.490
NOV	733.0	500.6	48.4	0.1021E 08	0.2552E 07	1521.8	1.611	0.242
DEC	566.3	787.4	39.6	0.1606E 08	0.2637E 07	1291.6	1.715	0.124
TOTAL		4071.2		0.8305E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.322

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	257.91
COLLECTOR TILT ANGLE (DEG) ....>>>	41.98
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0683
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0742
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1370
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2666
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.8748
HEAT EXCHANGER LENGTH (FT)	84.74
////////////////////CONSTRAINTS///////////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0628
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0059
COLLECTOR SIDE REYNOLDS NUMBER..........	0.569E 05
STORAGE SIDE REYNOLDS NUMBER	0.176E 06
CAPACITY RATIO (CMIN/CMAX)..................	0.0566
FLOW PARAMETER Z2(GCP/FRUL)...............	9.7798
FLOW PARAMETER Z1(GCP/FRUL)...............	9.27

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F)......	0.262E 04
STORAGE SIDE CAPACITY (BTU/HR F)........	0.463E 05
COLLECTOR SIDE CONVECTION COEFF..........	1142.1814
STORAGE SIDE CONVECTION COEFFICIENT	3769.5505
COLLECTOR SIDE FLOW RATE (GPM)	5.3729
STORAGE SIDE FLOW RATE (GPM)	92.9791
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3605
HEAT EXCHANGER EFFECTIVENESS............	0.8825
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.367E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3217
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.259E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	319.23
TOTAL INSTALLATION COST ($)	4674.96
COLLECTOR FLOW FACTOR(FPP)...............	0.9480

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                    S O L O A C - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

          DESIGN DATA OPTIONS/INPUTS SUMMARY

                    >>>>>DATA MATCH TO OUTPUT ID NO. 12223
                            IMOD-1 LWK AUGUST 1979
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LOCATION        RICHMOND        VA      COLLECTOR AMERICAN SUN                       STUDY APPROACH        ANALYSIS

LOCATION INDEX......          12        COLLECTOR TEST RESULTS,                      ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.50          SLOPE:
MEAN TEMPERATURE....       57.26          PARAMETER,FRUL....       1.0390
INSOL(BTU/DAY FT**2)     1247.82          INTERCEPT:                                 SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD)....     4071.20          PARAMETER,FRTA....       0.6380            DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....       55.00        BASE COST,$/FT**2...         6.55            INFLATION RATE......      0.1100
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ENERGY COMPARATIVE ESTIMATES                                        SELECTED PARAMETERS

TYPE ENERGY BASE.........................    OIL     COLLECTOR FLUID MEAN TEMPERATURE........         176.00
INDEX TYPE EFFICIENCY    COST        HEATING VALUE   COLLECTOR FLUID DENSITY(LB/FT**3).......          60.81
  1    OIL    0.70   0.90($/GAL)  142000.0(BTU/GAL)  COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).         1.0000
  2    ELE    0.99   0.05($/KWH)    3413.0(BTU/KWH)  COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)        0.3870
  3    GAS    0.70   0.40($/THM)  100000.0(BTU/THM)  STORAGE FLUID MEAN TEMPERATURE ........          104.00
                                                     STORAGE FLUID DENSITY(LB/FT**3).........          62.09
HEAT LOAD CHARACTERISTICS                            STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...         1.0000
                                                     STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).         0.3640
                                                     COLLECTOR SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                     STORAGE SIDE FOULING FACTOR(HR F/BTU)            0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09   HEX TUBE CONDUCTIVITY(BTU/HR FT F)......         220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....          15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99   ESTIMATED GROUND REFLECTANCE...........,           0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00   ESTIMATED PUMPING POWER(KWE/AREAC)......         1.0000
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00   ESTIMATED CORRECTION FOR TAU ALPHA PROD.           0.93
ESTIMATED DHW USERS (PER)...............      6.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..          10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00   ESTIMATED HEX COST ($/FT**2) ...........           5.00
                                                     ESTIMATED STORAGE TANK COST($/LB STORED)           0.06
                                                     MAINTENANCE (% INSTALLED COST/YR).......         0.0010
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12223
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSULATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.9	0.9392E 07	0.2637E 07	1419.3	1.619	0.164
FEB	876.0	722.9	39.4	0.7807E 07	0.2382E 07	1849.5	1.416	0.238
MAR	1210.2	572.7	46.6	0.6185E 07	0.2637E 07	2466.7	1.186	0.366
APR	1566.0	255.9	57.7	0.2764E 07	0.2552E 07	3100.2	1.001	0.595
MAY	1762.0	76.3	65.8	0.8240E 06	0.2637E 07	3554.9	0.888	0.792
JUN	1872.4	7.6	73.3	0.8208E 05	0.2552E 07	3749.4	0.843	0.894
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.864	0.895
AUG	1600.6	0.6	75.5	0.6480E 04	0.2637E 07	3290.7	0.951	0.887
SEP	1347.9	36.4	69.0	0.3931E 06	0.2552E 07	2706.3	1.112	0.818
OCT	1032.7	241.2	58.0	0.2605E 07	0.2637E 07	2047.8	1.350	0.542
NOV	733.0	500.6	48.4	0.5406E 07	0.2552E 07	1521.8	1.595	0.296
DEC	566.8	787.4	39.6	0.8504E 07	0.2637E 07	1291.6	1.695	0.160
TOTAL		4071.2		0.4397E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.400

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	207.20
COLLECTOR TILT ANGLE (DEG) ....>>>	39.86
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0630
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0702
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1301
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.0781
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.2643
HEAT EXCHANGER LENGTH (FT)	71.22
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0599
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0072
COLLECTOR SIDE REYNOLDS NUMBER..........	0.495E 05
STORAGE SIDE REYNOLDS NUMBER	0.155E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0546
FLOW PARAMETER Z2(GCP/FRUL).............	9.7700
FLOW PARAMETER Z1(GCP/FRPUL)............	9.26

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.210E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.385E 05
COLLECTOR SIDE CONVECTION COEFF.........	1106.7686
STORAGE SIDE CONVECTION COEFFICIENT	3550.4507
COLLECTOR SIDE FLOW RATE (GPM)	4.3123
STORAGE SIDE FLOW RATE (GPM)	77.3069
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3731
HEAT EXCHANGER EFFECTIVENESS............	0.8709
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.300E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.750E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3998
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.251E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	315.27
TOTAL INSTALLATION COST ($)	3753.37
COLLECTOR FLOW FACTOR(FPP).............	0.9479

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                    S O L A D - 1

     SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

          DESIGN DATA OPTIONS/INPUTS SUMMARY

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               >>>>>DATA MATCH TO OUTPUT ID NO. 12232
                            IMOD-1 LWK AUGUST 1979


LOCATION       RICHMOND        VA     COLLECTOR FEDERAL PRISON I. D       STUDY APPROACH          ANALYSIS
--------                              ---------                           --------------

LOCATION INDEX......          12      COLLECTOR TEST RESULTS,             ECONOMIC ESTIMATES
LATITUDE,DEGREES....       37.50        SLOPE:                            ------------------
MEAN TEMPERATURE....       57.26        PARAMETER,FRUL....     0.8830
INSOL(BTU/DAY FT**2)     1247.82        INTERCEPT:                        SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....     4071.20        PARAMETER,FRTA....     0.6270     DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....       55.00      BASE COST,$/FT**2...       9.40     INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                            SELECTED PARAMETERS
----------------------------                            -------------------

TYPE ENERGY BASE..........................      OIL    COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY    COST         HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)   COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)   COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)     0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)   STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                       STORAGE FLUID DENSITY(LB/FT**3).........      62.09
HEAT LOAD CHARACTERISTICS                              STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
-------------------------                              STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
                                                       COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                       STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.17    ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00    ESTIMATED GROUND REFLECTANCE...........,       0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   20399.99    ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00    ESTIMATED CORRECTION FOR TAU ALPHA PRED.       0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00    ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED DHW USERS (PER)...............       6.00    ESTIMATED HX COST ($/FT**2) ...........       5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00    ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                       MAINTENANCE (% INSTALLED COST/YR).......     0.0010
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR RICHMOND VA

>>>>>DATA MATCH TO INPUT ID NO. 12232
OMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	631.9	869.6	36.9	0.1774E 08	0.2637E 07	1419.3	1.624	0.126
FEB	876.0	722.9	39.4	0.1475E 08	0.2382E 07	1849.5	1.419	0.181
MAR	1210.2	572.7	46.6	0.1168E 08	0.2637E 07	2466.7	1.186	0.286
APR	1566.0	255.9	57.7	0.5220E 07	0.2552E 07	3100.2	0.999	0.520
MAY	1762.0	76.3	65.8	0.1557E 07	0.2637E 07	3554.9	0.884	0.802
JUN	1872.4	7.6	73.3	0.1550E 06	0.2552E 07	3749.4	0.839	0.961
JUL	1774.4	0.0	76.9	0.0	0.2637E 07	3660.6	0.860	0.968
AUG	1600.6	0.6	75.5	0.1224E 05	0.2637E 07	3290.7	0.948	0.960
SEP	1347.9	36.4	69.0	0.7425E 06	0.2552E 07	2706.3	1.111	0.863
OCT	1032.7	241.2	58.0	0.4920E 07	0.2637E 07	2047.8	1.352	0.481
NOV	733.0	500.6	48.4	0.1021E 08	0.2552E 07	1521.8	1.599	0.237
DEC	566.8	787.4	39.6	0.1606E 08	0.2637E 07	1291.6	1.700	0.125
TOTAL		4071.2		0.8305E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.322

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	237.34	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.190E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	40.42	STORAGE SIDE CAPACITY (BTU/HR F).......	0.441E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0610	COLLECTOR SIDE CONVECTION COEFF..........	1123.6265
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0683	STORAGE SIDE CONVECTION COEFFICIENT	3644.0984
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1336	COLLECTOR SIDE FLOW RATE (GPM)	4.0947
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1115	STORAGE SIDE FLOW RATE (GPM)	88.5919
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.0761	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0172
HEAT EXCHANGER LENGTH (FT)	93.43	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3733
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9372
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0653	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.367E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0073	TOTAL ENERGY DEMAND (BTU/YEAR)	0.114E 09
COLLECTOR SIDE REYNOLDS NUMBER.........	0.484E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3218
STORAGE SIDE REYNOLDS NUMBER	0.176E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.270E 04
CAPACITY RATIO (CMIN/CMAX).............	0.0452	HEX COEFFICIENT (BTU/HR F FT**2)........	317.38
FLOW PARAMETER Z2(GCP/FPUL)............	9.5067	TOTAL INSTALLATION COST ($)	4984.42
FLOW PARAMETER Z1(GCP/FPUL)............	9.00	COLLECTOR FLOW FACTOR(FPP)..............	0.9464

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*                 S O L O A D - 1                   *
*                                                   *
*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN   *
*    ---          -            -           -        *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                  >>>>>DATA MATCH TO OUTPUT ID NO. 13111
                                  IMOD-1 LWK AUGUST 1979


LOCATION         MONTEREY    CALIF    COLLECTOR SOLARMETICS                    STUDY APPROACH          ANALYSIS
--------                              ---------                                --------------

LOCATION INDEX......          13      COLLECTOR TEST RESULTS,                  ECONOMIC ESTIMATES
LATITUDE,DEGREES....       36.60         SLOPE:                                ------------------
MEAN TEMPERATURE....       56.40         PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)     1505.83         INTERCEPT:                            SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....     3140.00         PARAMETER,FRTA....       0.6910       DISCOUNT RATE ......        0.1150
MEAN GROUND TEMP....       55.00      BASE COST,$/FT**2...         12.98       INFLATION RATE......        0.1050


ENERGY COMPARATIVE ESTIMATES                            SELECTED PARAMETERS
----------------------------                            -------------------

TYPE ENERGY BASE.........................          OIL  COLLECTOR FLUID MEAN TEMPERATURE........          176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE       COLLECTOR FLUID DENSITY(LB/FT**3).......           60.81
  1    OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).          1.0000
  2    ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)          0.3870
  3    GAS      0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE ........           104.00
                                                        STORAGE FLUID DENSITY(LB/FT**3).........           62.09
                                                        STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...          1.0000
HEAT LOAD CHARACTERISTICS                               STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).          0.3640
-------------------------                               COLLECTOR SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                        STORAGE SIDE FOULING FACTOR(HR F/BTU)             0.0010
                                                        HEX TUBE CONDUCTIVITY(BTU/HR FT F)......          220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.25   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....           15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00   ESTIMATED GROUND REFLECTANCE...........,            0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........     30000.00   ESTIMATED PUMPING POWER(KWH/AREAC)......          1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.            0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..           10.00
ESTIMATED DHW USERS (PER)...............         6.00   ESTIMATED HEX COST ($/FT**2) ...........            5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00   ESTIMATED STORAGE TANK COST($/LB STORED)            0.08
                                                        MAINTENANCE (% INSTALLED COST/YR).......            0.01
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR MONTEREY CALIF

>>>>>DATA MATCH TO INPUT ID NO. 13111
UMCD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	720.0	434.0	51.4	0.1302E 08	0.2637E 07	1465.7	1.558	0.182
FEB	930.0	336.0	52.9	0.1008E 08	0.2382E 07	1892.2	1.383	0.265
MAR	1410.0	372.0	52.9	0.1116E 08	0.2637E 07	2500.1	1.195	0.346
APR	1930.0	333.0	53.9	0.9990E 07	0.2552E 07	3118.9	1.034	0.442
MAY	2210.0	282.0	55.9	0.8460E 07	0.2637E 07	3558.9	0.927	0.515
JUN	2320.0	201.0	58.3	0.6030E 07	0.2552E 07	3745.8	0.883	0.612
JUL	2240.0	174.0	59.4	0.5220E 07	0.2637E 07	3660.6	0.903	0.659
AUG	2020.0	136.0	60.6	0.4080E 07	0.2637E 07	3303.8	0.988	0.723
SEP	1650.0	84.0	62.2	0.2520E 07	0.2552E 07	2734.8	1.136	0.796
OCT	1180.0	136.0	60.6	0.4060E 07	0.2637E 07	2088.0	1.333	0.575
NOV	790.0	258.0	56.4	0.7740E 07	0.2552E 07	1567.5	1.516	0.286
DEC	620.0	394.0	52.3	0.1182E 08	0.2637E 07	1338.6	1.602	0.164
TOTAL		3140.0		0.9420E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.405

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	209.47
COLLECTOR TILT ANGLE (DEG) ....>>>	31.99
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0643
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0718
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1352
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.9100
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.9917
HEAT EXCHANGER LENGTH (FT)	87.86
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0634
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0075
COLLECTOR SIDE REYNOLDS NUMBER	0.477E 05
STORAGE SIDE REYNOLDS NUMBER	0.179E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0449
FLOW PARAMETER Z2(UCP/FPUL)............	9.5093
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.00

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.207E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.460E 05
COLLECTOR SIDE CONVECTION COEFF.........	1054.0122
STORAGE SIDE CONVECTION COEFFICIENT	3789.6926
COLLECTOR SIDE FLOW RATE (GPM)	4.2391
STORAGE SIDE FLOW RATE (GPM)	92.4648
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4414
HEAT EXCHANGER EFFECTIVENESS............	0.9259
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.507E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.125E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4046
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.207E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	312.38
TOTAL INSTALLATION COST ($)	6289.45
COLLECTOR FLOW FACTOR(FPP).............	0.9464

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*                                                   *
*               S O L O A D - 1                     *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*          DESIGN DATA OPTIONS/INPUTS SUMMARY       *
*                                                   *
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                  >>>>>DATA MATCH TO OUTPUT ID NO. 13112
                                IMOD-1 LWK AUGUST 1979


LOCATION      MONTEREY   CALIF     COLLECTOR SOLARNETICS                 STUDY APPROACH        ANALYSIS
--------                           ---------                             --------------

LOCATION INDEX......        13     COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....     36.60       SLOPE:                              ------------------
MEAN TEMPERATURE....     56.40       PARAMETER,FRUL....    1.0380
INSOL(BTU/DAY FT**2)   1505.83       INTERCEPT:                          SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....   3140.00       PARAMETER,FRTA....    0.6910        DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....     55.00     BASE COST,$/FT**2...   12.98          INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                           SELECTED PARAMETERS
----------------------------                           -------------------

TYPE ENERGY BASE.........................        OIL   COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1   OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)     COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2   ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)     COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3   GAS     0.70   0.40($/THM) 100000.0(BTU/THM)     STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                       STORAGE FLUID DENSITY(LB/FT**3).........        62.09
HEAT LOAD CHARACTERISTICS                              STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
-------------------------                              STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
                                                       COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                       STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00   ESTIMATED GROUND REFLECTANCE...........         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20399.99   ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00   ESTIMATED CORRECTION FOR TAU ALPHA FEED.         0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............        6.00   ESTIMATED HEX COST ($/FT**2) ..........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00   ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                       MAINTENANCE (% INSTALLED COST/YR).......         0.01
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*                 S O L O A D - 1                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*     RESULTS OF ANALYSIS FOR MONTEREY   CALIF      *
*                                                   *
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                    >>>>>DATA MATCH TO INPUT ID NO. 13112
                                 OMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	720.0	434.0	51.4	0.8854E 07	0.2637E 07	1465.7	1.557	0.155
FEB	980.0	336.0	52.9	0.6854E 07	0.2382E 07	1892.2	1.383	0.280
MAR	1410.0	372.0	52.9	0.7589E 07	0.2637E 07	2500.1	1.195	0.366
APR	1530.0	333.0	53.9	0.6793E 07	0.2552E 07	3118.9	1.035	0.463
MAY	2210.0	282.0	55.9	0.5753E 07	0.2637E 07	3558.9	0.927	0.533
JUN	2320.0	201.0	58.3	0.4100E 07	0.2552E 07	3745.8	0.883	0.620
JUL	2240.0	174.0	59.4	0.3550E 07	0.2637E 07	3660.6	0.904	0.661
AUG	2020.0	136.0	60.6	0.2774E 07	0.2637E 07	3303.8	0.988	0.714
SEP	1650.0	84.0	62.2	0.1714E 07	0.2552E 07	2734.8	1.136	0.768
OCT	1180.0	136.0	60.6	0.2774E 07	0.2637E 07	2088.0	1.332	0.567
NOV	790.0	258.0	56.4	0.5263E 07	0.2552E 07	1567.5	1.516	0.296
DEC	620.0	394.0	52.3	0.8038E 07	0.2637E 07	1338.6	1.601	0.174
TOTAL		3140.0		0.6406E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.420

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DESIGN VARIABLES/CONSTRAINTS
------------------------------
COLLECTOR AREA  (FT**2) ...............>>>       165.31
COLLECTOR TILT ANGLE  (DEG) ..........>>>        31.93
COLLECTOR SIDE TUBE INNER DIA. (FT) ....        0.0600
COLLECTOR SIDE TUBE OUTER DIA. (FT) ....        0.0700
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..        0.1289
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..        2.6478
STORAGE SIDE FLUID VELOCITY  (FT/SEC) ..       19.3912
HEAT EXCHANGER LENGTH (FT) .............         79.40
////////////////CONSTRAINTS/////////////////
HEX ANNULAR DIAMETER  DIFFERENCE (FT)....       0.0589
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).        0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........     0.405E 05
STORAGE SIDE REYNOLDS NUMBER ...........     0.161E 06
CAPACITY RATIO (CMIN/CMAX)..............        0.0411
FLOW PARAMETER Z2(GCP/FPUL)..............       9.5460
FLOW PARAMETER Z1(GCP/FRPUL).............         9.04

OTHER PARAMETERS
----------------
COLLECTOR SIDE CAPACITY (BTU/HR  F)..... 0.164E 04
STORAGE SIDE CAPACITY (BTU/HR  F)....... 0.399E 05
COLLECTOR SIDE CONVECTION COEFF.........  990.9626
STORAGE SIDE CONVECTION COEFFICIENT .... 3737.6292
COLLECTOR SIDE FLOW RATE  (GPM) ........    3.3584
STORAGE SIDE FLOW RATE  (GPM) ..........   80.0289
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...    0.0203
NORMALIZED STORAGE FLOW  (GPM/AREAC) ...    0.4841
HEAT EXCHANGER EFFECTIVENESS............    0.9345
SOLAR ENERGY DELIVERED (BTU/YEAR)....... 0.400E 08
TOTAL ENERGY DEMAND  (BTU/YEAR) ........ 0.951E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION .....    0.4201
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>> 0.162E 04
HEX COEFFICIENT (BTU/HR F FT**2)........    306.80
TOTAL INSTALLATION COST ($) ............   4969.24
COLLECTOR FLOW FACTOR(FPP)..............    0.9467
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*                S O L O A D - 1                    *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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                  >>>>>DATA MATCH TO OUTPUT ID NO. 13223
                                  IMOD-1 LWK AUGUST 1979


LOCATION        MONTEREY   CALIF      COLLECTOR AMERICAN SUN                STUDY APPROACH        ANALYSIS
--------                              ---------                             --------------

LOCATION INDEX......          13      COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....       36.60        SLOPE:                              ------------------
MEAN TEMPERATURE....       56.40        PARAMETER,FRUL....     1.0390
INSOL(BTU/DAY FT**2)     1505.83        INTERCEPT:                          SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....     3140.00        PARAMETER,FRTA....     0.6380       DISCOUNT RATE ......     0.0900
MEAN GROUND TEMP....       55.00      BASE COST,$/FT**2...       6.55       INFLATION RATE......     0.1100


ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS
----------------------------                               -------------------

TYPE ENERGY BASE.................................OIL       COLLECTOR FLUID MEAN TEMPERATURE.........          176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3)........           60.81
  1   OIL    0.70   0.90($/GAL)  142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).           1.0000
  2   ELE    0.99   0.05($/KWH)    3413.0(BTU/KWH)         COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)          0.3970
  3   GAS    0.70   0.40($/THM)  100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE ........          104.00
                                                           STORAGE FLUID DENSITY(LB/FT**3).........            62.09
HEAT LOAD CHARACTERISTICS                                  STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...           1.0000
-------------------------                                  STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).           0.3640
                                                           COLLECTOR SIDE FOULING FACTOR(HR F/BTU)            0.0010
                                                           STORAGE SIDE FOULING FACTOR(HR F/BTU)              0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.09         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......          220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....           15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........  10799.99         ESTIMATED GROUND REFLECTANCE...........,            0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00         ESTIMATED PUMPING POWER(KWH/AREAC).....            1.0000
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00         ESTIMATED CORRECTION FOR TAU ALPHA PRED.            0.93
ESTIMATED DHW USERS (PER)...............      6.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..           10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00         ESTIMATED HEX COST ($/FT**2) ..........             5.00
                                                           ESTIMATED STORAGE TANK COST($/LB STORED)            0.08
                                                           MAINTENANCE (% INSTALLED COST/YR).......           0.0010
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR MONTEREY CALIF

>>>>>DATA MATCH FC INPUT ID NO. 13223
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	720.0	434.0	51.4	0.4687E 07	0.2637E 07	1465.7	1.593	0.374
FEB	980.0	336.0	52.9	0.3629E 07	0.2382E 07	1892.2	1.403	0.507
MAR	1410.0	372.0	52.9	0.4018E 07	0.2637E 07	2500.1	1.200	0.633
APR	1930.0	333.0	53.9	0.3596E 07	0.2552E 07	3118.9	1.025	0.755
MAY	2210.0	282.0	55.9	0.3046E 07	0.2637E 07	3558.9	0.909	0.816
JUN	2320.0	201.0	58.3	0.2171E 07	0.2552E 07	3745.8	0.862	0.877
JUL	2240.0	174.0	59.4	0.1379E 07	0.2637E 07	3660.6	0.884	0.901
AUG	2020.0	136.0	60.6	0.1469E 07	0.2637E 07	3303.8	0.975	0.931
SEP	1650.0	84.0	62.2	0.9072E 06	0.2552E 07	2734.8	1.135	0.945
OCT	1180.0	136.0	60.6	0.1469E 07	0.2637E 07	2088.0	1.348	0.795
NOV	790.0	258.0	56.4	0.2786E 07	0.2552E 07	1567.5	1.548	0.510
DEC	620.0	394.0	52.3	0.4255E 07	0.2637E 07	1338.6	1.641	0.332
TOTAL		3140.0		0.3391E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.660

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	249.27
COLLECTOR TILT ANGLE (DEG) ....>>>	35.10
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0749
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0799
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1392
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.6721
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.0354
HEAT EXCHANGER LENGTH (FT)	76.22
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0593
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.511E 05
STORAGE SIDE REYNOLDS NUMBER	0.159E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0594
FLOW PARAMETER Z2(GCP/FPUL).............	9.9587
FLOW PARAMETER Z1(GCP/FRPUL)............	9.45

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.253E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.434E 05
COLLECTOR SIDE CONVECTION COEFF.........	954.7993
STORAGE SIDE CONVECTION COEFFICIENT	3654.8030
COLLECTOR SIDE FLOW RATE (GPM)	5.2880
STORAGE SIDE FLOW RATE (GPM)	87.1958
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0212
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3498
HEAT EXCHANGER EFFECTIVENESS............	0.8682
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.429E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.650E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6599
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.451E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	301.67
TOTAL INSTALLATION COST ($)	4520.15
COLLECTOR FLOW FACTOR(FPP)..............	0.9489

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S O L I A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 13232
IMCO-1 LNK AUGUST 1979
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LOCATION            MONTEREY   CALIF

LOCATION INDEX......           13
LATITUDE,DEGREES....        35.60
MEAN TEMPERATURE....        56.40
INSOL(BTU/DAY FT**2)      1505.83
LOAD FACTOR,HD).....      3140.00
MEAN GROUND TEMP....        55.00
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COLLECTOR FEDERAL PRISON I. D

COLLECTOR TEST RESULTS,
  SLOPE:
   PARAMETER,FRUL....      0.8830
   INTERCEPT:
   PARAMETER,FRTA....      0.6270
BASE COST,$/FT**2...         9.40
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STUDY APPROACH              ANALYSIS

ECONOMIC ESTIMATES

SYSTEM LIFE(YEARS)..          20.00
DISCOUNT RATE ......          0.0900
INFLATION RATE......          0.1100
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ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE.............................        OIL
INDEX TYPE EFFICIENCY   COST          HEATING VALUE
  1    OIL    0.70   0.90($/GAL)  142000.0(BTU/GAL)
  2    ELC    0.99   0.05($/KWH)    3413.0(BTU/KWH)
  3    GAS    0.70   0.40($/THM)  100000.0(BTU/THM)
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HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........     20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00
ESTIMATED DHW USERS (PER)...............         6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00
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SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........        176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
STORAGE FLUID MEAN TEMPERATURE ........         104.00
STORAGE FLUID DENSITY(LB/FT**3).........         62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
ESTIMATED GROUND REFLECTANCE...........           0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED HEX COST ($/FT**2) ..........           5.00
ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR MONTEREY CALIF

>>>>>DATA MATCH TO INPUT ID NO. 13232
MOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	720.0	434.0	51.4	0.8854E 07	0.2637E 07	1465.7	1.589	0.345
FEB	980.0	336.0	52.9	0.6854E 07	0.2382E 07	1892.2	1.401	0.474
MAR	1410.0	372.0	52.9	0.7589E 07	0.2637E 07	2500.1	1.199	0.592
APR	1930.0	333.0	53.9	0.6793E 07	0.2552E 07	3118.9	1.026	0.717
MAY	2210.0	282.0	55.9	0.5753E 07	0.2637E 07	3558.9	0.912	0.795
JUN	2320.0	201.0	58.3	0.4100E 07	0.2552E 07	3745.8	0.865	0.884
JUL	2240.0	174.0	59.4	0.3550E 07	0.2637E 07	3660.6	0.887	0.921
AUG	2020.0	136.0	60.6	0.2774E 07	0.2637E 07	3303.8	0.977	0.967
SEP	1650.0	84.0	62.2	0.1714E 07	0.2552E 07	2734.8	1.135	1.000
OCT	1180.0	135.0	60.6	0.2774E 07	0.2637E 07	2088.0	1.346	0.833
NOV	790.0	258.0	56.4	0.5263E 07	0.2552E 07	1567.5	1.544	0.499
DEC	620.0	394.0	52.3	0.8038E 07	0.2637E 07	1338.6	1.636	0.313
TOTAL		3140.0		0.6106E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.637

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	332.01	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.279E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	34.57	STORAGE SIDE CAPACITY (BTU/HR F).......	0.378E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0709	COLLECTOR SIDE CONVECTION COEFF..........	1122.7029
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0768	STORAGE SIDE CONVECTION COEFFICIENT	3496.7009
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1339	COLLECTOR SIDE FLOW RATE (GPM)	5.7145
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2268	STORAGE SIDE FLOW RATE (GPM)	75.8878
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.8300	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0172
HEAT EXCHANGER LENGTH (FT)	74.55	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2286
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8560
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0571	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.606E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0059	TOTAL ENERGY DEMAND (BTU/YEAR)	0.951E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.583E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.6370
STORAGE SIDE REYNOLDS NUMBER	0.144E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.585E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0737	HEX COEFFICIENT (BTU/HR F FT**2)........	315.70
FLOW PARAMETER Z2(GCP/FPUL).............	9.5075	TOTAL INSTALLATION COST ($)	6930.39
FLOW PARAMETER Z1(GCP/FRPUL)............	9.00	COLLECTOR FLOW FACTOR(FPP)..............	0.9464

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*                S O L O A C - 1                    *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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                  >>>>>DATA MATCH TO OUTPUT ID NO. 14111
                              IMOD-1 LWK AUGUST 1979


LOCATION       FRESNO      CALIF     COLLECTOR SOLARNETICS                         STUDY APPROACH          ANALYSIS
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LOCATION INDEX......           14    COLLECTOR TEST RESULTS,                       ECONOMIC ESTIMATES
LATITUDE,DEGREES....        36.77      SLOPE:                                      ------------------
MEAN TEMPERATURE....        61.85      PARAMETER,FRUL....       1.0380
INSOL(BTU/DAY FT**2)      1710.81      INTERCEPT:                                  SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....      2826.40      PARAMETER,FRTA....       0.6910             DISCOUNT RATE ......       0.1150
MEAN GROUND TEMP....        55.00    BASE COST,$/FT**2...      12.98               INFLATION RATE......       0.1050


ENERGY COMPARATIVE ESTIMATES                           SELECTED PARAMETERS
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TYPE ENERGY BASE..........................       OIL   COLLECTOR FLUID MEAN TEMPERATURE.........      176.00
INDEX TYPE EFFICIENCY    COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3)........       60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)    COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).      1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)    COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)      0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)    STORAGE FLUID MEAN TEMPERATURE .........      104.00
                                                       STORAGE FLUID DENSITY(LB/FT**3)..........       62.09
                                                       STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...      1.0000
HEAT LOAD CHARACTERISTICS                              STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).      0.3640
-------------------------                              COLLECTOR SIDE FOULING FACTOR(HR F/BTU)       0.0010
                                                       STORAGE SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......      220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.25   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....       15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00   ESTIMATED GROUND REFLECTANCE............        0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    30000.00   ESTIMATED PUMPING POWER(KWH/AREAC)......      1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00   ESTIMATED CORRECTION FOR TAU ALPHA PRED.        0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..       10.00
ESTIMATED DHW USERS (PER)...............        6.00   ESTIMATED HEX COST ($/FT**2) ...........        5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00   ESTIMATED STORAGE TANK COST($/LB STORED)        0.08
                                                       MAINTENANCE (% INSTALLED COST/YR).......        0.01
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SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR FRESNO CALIF

>>>>>DATA MATCH TO INPUT ID NO. 14111
OMDC-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	657.0	640.7	44.3	0.1922E 08	0.2637E 07	1456.9	1.571	0.063
FEB	1012.0	442.4	49.3	0.1327E 08	0.2382E 07	1884.2	1.425	0.130
MAR	1566.0	349.7	53.8	0.1049E 08	0.2637E 07	2493.8	1.222	0.241
APR	2093.0	187.0	59.6	0.5610E 07	0.2552E 07	3115.4	1.028	0.409
MAY	2484.0	55.6	67.5	0.1668E 07	0.2637E 07	3558.2	0.901	0.718
JUN	2733.0	5.3	75.3	0.1590E 06	0.2552E 07	3746.5	0.846	0.951
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.871	0.992
AUG	2423.0	0.3	78.7	0.9000E 04	0.2637E 07	3301.4	0.977	0.995
SEP	1985.0	4.1	73.2	0.1230E 06	0.2552E 07	2729.5	1.165	0.953
OCT	1429.0	105.3	63.2	0.3159E 07	0.2637E 07	2080.5	1.416	0.522
NOV	888.6	394.3	51.9	0.1183E 08	0.2552E 07	1558.9	1.616	0.150
DEC	574.1	641.7	44.3	0.1925E 08	0.2637E 07	1329.8	1.624	0.053
TOTAL		2826.4		0.8479E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.256

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	112.47
COLLECTOR TILT ANGLE (DEG) ....>>>	36.30
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0504
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0575
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1129
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.5788
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.1631
HEAT EXCHANGER LENGTH (FT)	46.52
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0554
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0071
COLLECTOR SIDE REYNOLDS NUMBER..........	0.332E 05
STORAGE SIDE REYNOLDS NUMBER	0.126E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0421
FLOW PARAMETER Z2(GCP/FRUL)............	9.6521
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.14

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.113E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.268E 05
COLLECTOR SIDE CONVECTION COEFF.........	1004.5793
STORAGE SIDE CONVECTION COEFFICIENT	3282.9099
COLLECTOR SIDE FLOW RATE (GPM)	2.3102
STORAGE SIDE FLOW RATE (GPM)	53.7832
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.4782
HEAT EXCHANGER EFFECTIVENESS............	0.8574
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.297E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.116E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2563
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.153E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	305.11
TOTAL INSTALLATION COST ($)	5364.13
COLLECTOR FLOW FACTOR(FPP)..............	0.9473

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*              S O L O A D - 1                         *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN       *
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*        DESIGN DATA OPTIONS/INPUTS SUMMARY            *
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            >>>>>DATA MATCH TO OUTPUT ID NO. 14112
                         IMOD-1 LWK AUGUST 1979


LOCATION       FRESNO      CALIF    COLLECTOR SOLARNETICS                  STUDY APPROACH        ANALYSIS
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LOCATION INDEX......          14    COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....       36.77      SLOPE:                               ------------------
MEAN TEMPERATURE....       61.85       PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)     1710.81       INTERCEPT:                          SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....     2826.40       PARAMETER,FRTA....      0.6910      DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....       55.00    BASE COST,$/FT**2...      12.98        INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                          SELECTED PARAMETERS
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TYPE ENERGY BASE..........................       OIL  COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE     COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)   COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)   COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)        0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)   STORAGE FLUID MEAN TEMPERATURE ........         104.00
                                                      STORAGE FLUID DENSITY(LB/FT**3)........          62.09
                                                      STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                             STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                             COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                      STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                      HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..       0.17   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..    5000.00   ESTIMATED GROUND REFLECTANCE...........,          0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........   20399.99   ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...     140.00   ESTIMATED CORRECTION FOR TAU ALPHA PROD.          0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...      20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED DHW USERS (PER)...............       6.00   ESTIMATED HEX COST ($/FT**2) ...........          5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.       1.00   ESTIMATED STORAGE TANK COST($/LB STORED)          0.08
                                                      MAINTENANCE (% INSTALLED COST/YR).......          0.01
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SOLJAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR FRESNO CALIF

>>>>>DATA MATCH TO INPUT ID NO. 14112
UMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	657.0	640.7	44.3	0.1307E 08	0.2637E 07	1456.9	1.569	0.080
FEB	1012.0	442.4	49.3	0.9025E 07	0.2382E 07	1884.2	1.424	0.163
MAR	1566.0	349.7	53.8	0.7134E 07	0.2637E 07	2493.8	1.222	0.295
APR	2093.0	187.0	59.6	0.3815E 07	0.2552E 07	3115.4	1.029	0.474
MAY	2484.0	55.6	67.5	0.1134E 07	0.2637E 07	3558.2	0.903	0.749
JUN	2733.0	5.3	75.3	0.1081E 06	0.2552E 07	3746.5	0.848	0.930
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.873	0.964
AUG	2423.0	0.3	78.7	0.6120E 04	0.2637E 07	3301.4	0.978	0.967
SEP	1985.0	4.1	73.2	0.8364E 05	0.2552E 07	2729.5	1.166	0.930
OCT	1429.0	105.3	63.2	0.2148E 07	0.2637E 07	2060.5	1.415	0.573
NOV	888.0	394.3	51.9	0.8044E 07	0.2552E 07	1558.9	1.613	0.186
DEC	574.1	641.7	44.3	0.1309E 08	0.2637E 07	1329.8	1.621	0.068
TOTAL		2826.4		0.5766E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.312

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	104.22	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.106E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	36.03	STORAGE SIDE CAPACITY (BTU/HR F).......	0.278E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0477	COLLECTOR SIDE CONVECTION COEFF.........	1052.9441
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0577	STORAGE SIDE CONVECTION COEFFICIENT	3296.7952
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1143	COLLECTOR SIDE FLOW RATE (GPM)	2.1680
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.6980	STORAGE SIDE FLOW RATE (GPM)	55.8983
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.3024	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0208
HEAT EXCHANGER LENGTH (FT)	55.74	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.5363
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9090
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0565	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.277E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.887E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.329E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3117
STORAGE SIDE REYNOLDS NUMBER	0.130E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.144E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0380	HEX COEFFICIENT (BTU/HR F FT**2)........	310.45
FLOW PARAMETER Z2(GCP/FRUL).............	9.7746	TOTAL INSTALLATION COST ($)	3126.48
FLOW PARAMETER Z1(GCP/FRPUL)............	9.27	COLLECTOR FLOW FACTOR(FPP)..............	0.9479

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                  >>>>>DATA MATCH TO OUTPUT ID NO. 14223
                                IMOD-1 LWK AUGUST 1979
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LOCATION	FRESNO	CALIF
LOCATION INDEX......		14
LATITUDE,DEGREES....		36.77
MEAN TEMPERATURE....		61.85
INSOL(BTU/DAY FT**2)		1710.81
LOAD FACTOR,HDD.....		2826.40
MEAN GROUND TEMP....		55.00

COLLECTOR AMERICAN SUN	
COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL....	1.0390
INTERCEPT:	
PARAMETER,FRTA....	0.6380
BASE COST,$/FT**2...	6.55

STUDY APPROACH	ANALYSIS
ECONOMIC ESTIMATES	
SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE................................ OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.09
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	10799.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER)...............	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLD CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PEED.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR FRESNO CALIF

>>>>>DATA MATCH TO INPUT ID NO. 14223
IMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	657.0	640.7	44.3	0.6920E 07	0.2637E 07	1456.5	1.630	0.176
FEB	1012.0	442.4	49.3	0.4778E 07	0.2382E 07	1384.2	1.458	0.332
MAR	1566.0	349.7	53.8	0.3777E 07	0.2637E 07	2493.8	1.221	0.536
APR	2093.0	187.0	59.6	0.2020E 07	0.2552E 07	3115.4	0.996	0.726
MAY	2484.0	55.6	67.5	0.6005E 06	0.2637E 07	3558.2	0.851	0.911
JUN	2733.0	5.3	75.3	0.5724E 05	0.2552E 07	3746.5	0.789	1.000
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.816	1.000
AUG	2423.0	0.3	78.7	0.3240E 04	0.2637E 07	3301.4	0.937	1.000
SEP	1985.0	4.1	73.2	0.4428E 05	0.2552E 07	2729.5	1.153	1.000
OCT	1429.0	105.3	63.2	0.1137E 07	0.2637E 07	2080.5	1.445	0.825
NOV	888.6	394.3	51.9	0.4258E 07	0.2552E 07	1558.9	1.679	0.374
DEC	574.1	641.7	44.3	0.6930E 07	0.2637E 07	1329.8	1.691	0.150
TOTAL		2826.4		0.3053E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.509

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	159.23	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.160E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	43.41	STORAGE SIDE CAPACITY (BTU/HR F).......	0.288E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0510	COLLECTOR SIDE CONVECTION COEFF.........	1301.8782
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0575	STORAGE SIDE CONVECTION COEFFICIENT	3251.1172
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1161	COLLECTOR SIDE FLOW RATE (GPM)	3.2776
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.5760	STORAGE SIDE FLOW RATE (GPM)	57.8095
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.1076	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0206
HEAT EXCHANGER LENGTH (FT)	52.36	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3630
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8114
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0536	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.313E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0065	TOTAL ENERGY DEMAND (BTU/YEAR)	0.616E 08
COLLECTOR SIDE REYNOLDS NUMBER..........	0.465E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.5091
STORAGE SIDE REYNOLDS NUMBER	0.133E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.377E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0555	HEX COEFFICIENT (BTU/HR F FT**2).......	327.35
FLOW PARAMETER Z2(SUP/FRUL).............	9.5628	TOTAL INSTALLATION COST ($)	2872.16
FLOW PARAMETER Z1(CCP/FRUL).............	9.15	COLLECTOR FLOW FACTOR(FPP)..............	0.9473

SOLOAD - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR FRESNO CALIF

>>>>>DATA MATCH TO INPUT ID NO. 14232
SMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	657.0	640.7	44.3	0.1307E 08	0.2637E 07	1456.9	1.640	0.142
FEB	1012.0	442.4	49.3	0.9025E 07	0.2382E 07	1884.2	1.463	0.270
MAR	1566.0	349.7	53.8	0.7134E 07	0.2637E 07	2493.8	1.219	0.452
APR	2093.0	187.0	59.6	0.3815E 07	0.2552E 07	3115.4	0.987	0.666
MAY	2484.0	55.6	67.5	0.1134E 07	0.2637E 07	3558.2	0.839	0.937
JUN	2733.0	5.3	75.3	0.1081E 06	0.2552E 07	3746.5	0.775	1.000
JUL	2685.0	0.0	81.1	0.0	0.2637E 07	3660.6	0.803	1.000
AUG	2423.0	0.3	78.7	0.6120E 04	0.2637E 07	3301.4	0.926	1.000
SEP	1985.0	4.1	73.2	0.8364E 05	0.2552E 07	2729.5	1.149	1.000
OCT	1429.0	105.3	63.2	0.2148E 07	0.2637E 07	2080.5	1.449	0.821
NOV	888.6	394.3	51.9	0.8044E 07	0.2552E 07	1558.9	1.690	0.313
DEC	574.1	641.7	44.3	0.1309E 08	0.2637E 07	1329.8	1.703	0.122
TOTAL		2826.4		0.5766E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.420

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	188.05
COLLECTOR TILT ANGLE (DEG) ....>>>	45.00
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0540
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0590
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1189
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2538
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.6628
HEAT EXCHANGER LENGTH (FT)	59.43
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0599
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050
COLLECTOR SIDE REYNOLDS NUMBER..........	0.443E 05
STORAGE SIDE REYNOLDS NUMBER	0.141E 06
CAPACITY RATIO (CMIN/CMAX)..............	0.0523
FLOW PARAMETER Z2(GCP/FOUL).............	9.3039
FLOW PARAMETER Z1(GCP/FRPUL)............	9.30

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.163E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.312E 05
COLLECTOR SIDE CONVECTION COEFF.........	1193.5864
STORAGE SIDE CONVECTION COEFFICIENT	3328.1152
COLLECTOR SIDE FLOW RATE (GPM)	3.3397
STORAGE SIDE FLOW RATE (GPM)	62.5827
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0178
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3328
HEAT EXCHANGER EFFECTIVENESS............	0.8537
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.372E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.887E 08
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4196
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.395E 04
HEX COEFFICIENT (BTU/HR F FT**2)........	520.14
TOTAL INSTALLATION COST ($)	3928.72
COLLECTOR FLOW FACTOR(FPP).............	0.9481

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*               S O L O A D - 1                 *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
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*     DESIGN DATA OPTIONS/INPUTS SUMMARY        *
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              >>>>>DATA MATCH TO OUTPUT ID NO. 15111
                               IMOD-1 LWK AUGUST 1979


LOCATION        TULSA   OKLAHOMA    COLLECTOR SOLARMETICS                      STUDY APPROACH        ANALYSIS
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LOCATION INDEX......         15     COLLECTOR TEST RESULTS,                    ECONOMIC ESTIMATES
LATITUDE,DEGREES....      36.20       SLOPE:                                   ------------------
MEAN TEMPERATURE....      59.81       PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)    1373.47       INTERCEPT:                               SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,HDD.....    3804.40       PARAMETER,FRTA....      0.6910           DISCOUNT RATE ......      0.1150
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...       12.98           INFLATION RATE......      0.1050


ENERGY COMPARATIVE ESTIMATES                                SELECTED PARAMETERS
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TYPE ENERGY BASE.........................          OIL      COLLECTOR FLUID MEAN TEMPERATURE.........       176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE         COLLECTOR FLUID DENSITY(LB/FT**3)........        60.81
  1   OIL      0.70   0.90($/GAL) 142000.0(BTU/GAL)         COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2   ELE      0.99   0.05($/KWH)   3413.0(BTU/KWH)         COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)        0.3870
  3   GAS      0.70   0.40($/THM) 100000.0(BTU/THM)         STORAGE FLUID MEAN TEMPERATURE .........       104.00
                                                            STORAGE FLUID DENSITY(LB/FT**3).........        62.09
                                                            STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
HEAT LOAD CHARACTERISTICS                                   STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
-------------------------                                   COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                            STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                            HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.25        ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00        ESTIMATED GROUND REFLECTANCE...........,         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........    30000.00        ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00        ESTIMATED CORRECTION FOR TAU ALPHA PRED.         0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00        ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)...............        6.00        ESTIMATED HEX COST ($/FT**2) ...........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00        ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                            MAINTENANCE (% INSTALLED COST/YR).......         0.01
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*                 S O L O A D - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*      RESULTS OF ANALYSIS FOR TULSA   OKLAHOMA     *
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                  >>>>>DATA MATCH TO INPUT ID NO. 15111
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.2720E 08	0.2637E 07	1486.3	1.591	0.050
FEB	978.0	681.3	40.9	0.2044E 08	0.2382E 07	1911.1	1.396	0.076
MAR	1306.0	513.7	48.8	0.1541E 08	0.2637E 07	2514.7	1.182	0.126
APR	1603.0	180.3	60.8	0.5409E 07	0.2552E 07	3126.9	1.008	0.282
MAY	1822.0	45.0	68.9	0.1350E 07	0.2637E 07	3560.5	0.905	0.534
JUN	2021.0	1.8	77.0	0.5400E 05	0.2552E 07	3744.0	0.861	0.748
JUL	2031.0	0.3	82.2	0.9000E 04	0.2637E 07	3660.4	0.880	0.781
AUG	1865.0	0.1	80.7	0.3000E 04	0.2637E 07	3309.3	0.966	0.785
SEP	1473.0	21.5	72.7	0.6450E 06	0.2552E 07	2747.3	1.115	0.515
OCT	1164.0	163.0	61.9	0.4890E 07	0.2637E 07	2105.7	1.339	0.293
NOV	827.4	490.8	48.8	0.1472E 08	0.2552E 07	1587.8	1.558	0.100
DEC	659.3	799.9	39.2	0.2400E 08	0.2637E 07	1359.5	1.660	0.051
TOTAL		3804.4		0.1141E 09	0.3105E 08			
						>>>WEIGHTED	AVERAGE	0.160

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	102.70
COLLECTOR TILT ANGLE (DEG) ....>>>	35.81
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0518
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0618
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1203
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.1878
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.1121
HEAT EXCHANGER LENGTH (FT)	55.24
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0584
COLLECTOR SIDE TUBE DIA. DIFFER EACH(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER...........	0.289E 05
STORAGE SIDE REYNOLDS NUMBER	0.149E 06
CAPACITY RATIO (CMIN/CMAX)...............	0.0299
FLOW PARAMETER Z2(GCP/FRUL)..............	9.4779
FLOW PARAMETER Z1(GCP/FRPUL).............	8.97

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.101E 04
STORAGE SIDE CAPACITY (BTU/HR F).......	0.338E 05
COLLECTOR SIDE CONVECTION COEFF.........	875.8982
STORAGE SIDE CONVECTION COEFFICIENT	3562.8655
COLLECTOR SIDE FLOW RATE (GPM)	2.0714
STORAGE SIDE FLOW RATE (GPM)	67.9400
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.6616
HEAT EXCHANGER EFFECTIVENESS............	0.9234
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.232E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.145E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1600
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.746E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	294.31
TOTAL INSTALLATION COST ($)	3085.23
COLLECTOR FLOW FACTOR(FPP)..............	0.9463

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*                 S O L O A D - 1                   *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*          DESIGN DATA OPTIONS/INPUTS SUMMARY       *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 15112
                                    IMOD-1 LWK AUGUST 1979


LOCATION      TULSA   OKLAHOMA     COLLECTOR SOLARNETICS              STUDY APPROACH        ANALYSIS
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LOCATION INDEX......        15     COLLECTOR TEST RESULTS,            ECONOMIC ESTIMATES
LATITUDE,DEGREES....     36.20       SLOPE:                           ------------------
MEAN TEMPERATURE....     59.81        PARAMETER,FRUL....     1.0380
INSOL(BTU/DAY FT**2)   1373.47       INTERCEPT:                       SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....   3804.40        PARAMETER,FR TA....    0.6910   DISCOUNT RATE ......    0.1150
MEAN GROUND TEMP....     55.00     BASE COST,$/FT**2...     12.98     INFLATION RATE......    0.1050


ENERGY COMPARATIVE ESTIMATES                         SELECTED PARAMETERS
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TYPE ENERGY BASE.........................   OIL      COLLECTOR FLUID MEAN TEMPERATURE........         176.00
INDEX TYPE EFFICIENCY   COST        HEATING VALUE    COLLECTOR FLUID DENSITY(LB/FT**3)........         60.81
  1    OIL     0.70   0.90($/GAL) 142000.0(BTU/GAL)  COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).         1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)  COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)        0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)  STORAGE FLUID MEAN TEMPERATURE ........         104.00
                                                     STORAGE FLUID DENSITY(LB/FT**3).........          62.09
                                                     STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...         1.0000
HEAT LOAD CHARACTERISTICS                            STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).         0.3640
-------------------------                            COLLECTOR SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                     STORAGE SIDE FOULING FACTOR(HR F/BTU)            0.0010
                                                     HEX TUBE CONDUCTIVITY(BTU/HR FT F)......         220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..      0.17   ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....          15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..   5000.00   ESTIMATED GROUND REFLECTANCE..........,           0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........  20399.99   ESTIMATED PUMPING POWER(KWH/AREAC)......         1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...    140.00   ESTIMATED CORRECTION FOR TAU ALPHA PFED.           0.93
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...     20.00   ESTIMATED INSTALL/LABOR COST ($/AREAC)..          10.00
ESTIMATED DHW USERS (PER)...............      6.00   ESTIMATED HEX COST ($/FT**2) ...........           5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.      1.00   ESTIMATED STORAGE TANK COST($/LB STORED)           0.08
                                                     MAINTENANCE (% INSTALLED COST/YR).......           0.01
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S O L O A C - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR TULSA OKLAHOMA

>>>>>DATA MATCH TO INPUT ID NO. 15112
'IMOD-1 LWK AUGUST 1975

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.1850E 08	0.2637E 07	1486.3	1.600	0.069
FEB	978.0	681.3	40.9	0.1390E 08	0.2382E 07	1911.1	1.401	0.103
MAR	1306.0	513.7	48.8	0.1048E 08	0.2637E 07	2514.7	1.182	0.166
APR	1603.0	180.3	60.8	0.3678E 07	0.2552E 07	3126.9	1.005	0.341
MAY	1822.0	45.0	68.9	0.9180E 06	0.2637E 07	3560.5	0.900	0.568
JUN	2021.0	1.8	77.0	0.3672E 05	0.2552E 07	3744.0	0.855	0.735
JUL	2031.0	0.3	82.2	0.6120E 04	0.2637E 07	3660.4	0.874	0.766
AUG	1865.0	0.1	80.7	0.2040E 04	0.2637E 07	3309.3	0.962	0.771
SEP	1473.0	21.5	72.7	0.4386E 06	0.2552E 07	2747.3	1.114	0.632
OCT	1164.0	163.0	61.9	0.3325E 07	0.2637E 07	2105.7	1.342	0.352
NOV	827.4	490.8	48.8	0.1001E 08	0.2552E 07	1587.8	1.566	0.133
DEC	659.3	799.9	39.2	0.1632E 08	0.2637E 07	1359.5	1.670	0.070
TOTAL		3804.4		0.7761E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.206

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	36.67
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0479
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0579
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1207
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.4993
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	18.3064
HEAT EXCHANGER LENGTH (FT)	60.57
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0627
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.306E 05
STORAGE SIDE REYNOLDS NUMBER	0.162E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0274
FLOW PARAMETER Z2(GCP/FRUL)............	9.5092
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.00

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.987E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.360E 05
COLLECTOR SIDE CONVECTION COEFF.........	989.6692
STORAGE SIDE CONVECTION COEFFICIENT	3577.6553
COLLECTOR SIDE FLOW RATE (GPM)	2.0237
STORAGE SIDE FLOW RATE (GPM)	72.3214
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.7232
HEAT EXCHANGER EFFECTIVENESS............	0.9380
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.224E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.109E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2062
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.690E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	306.53
TOTAL INSTALLATION COST ($)	3006.36
COLLECTOR FLOW FACTOR(FFP).............	0.9464

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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN      *
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*          DESIGN DATA OPTIONS/INPUTS SUMMARY         *
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               >>>>>DATA MATCH TO OUTPUT ID NO. 15223
                              IMOD-1 LWK AUGUST 1979


LOCATION      TULSA   OKLAHOMA      COLLECTOR AMERICAN SUN            STUDY APPROACH        ANALYSIS
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LOCATION INDEX......          15    COLLECTOR TEST RESULTS,           ECONOMIC ESTIMATES
LATITUDE,DEGREES....       36.20      SLOPE:                          ------------------
MEAN TEMPERATURE....       59.81      PARAMETER,FRUL....     1.0390
INSOL (BTU/DAY FT**2)    1373.47      INTERCEPT:                      SYSTEM LIFE(YEARS)..     20.00
LOAD FACTOR,HDD.....     3804.40      PARAMETER,FRTA....     0.6380   DISCOUNT RATE ......    0.0900
MEAN GROUND TEMP....       55.00    BASE COST,$/FT**2...       6.55   INFLATION RATE......    0.1100


ENERGY COMPARATIVE ESTIMATES                             SELECTED PARAMETERS
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TYPE ENERGY BASE...........................         OIL  COLLECTOR FLUID MEAN TEMPERATURE........     176.00
INDEX TYPE EFFICIENCY    COST         HEATING VALUE      COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL     0.70   0.50($/GAL) 142000.0(BTU/GAL)      COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE     0.99   0.05($/KWH)   3413.0(BTU/KWH)      COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)      STORAGE FLUID MEAN TEMPERATURE ........      104.00
                                                         STORAGE FLUID DENSITY(LB/FT**3).........      62.09
HEAT LOAD CHARACTERISTICS                                STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
-------------------------                                STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3740
                                                         COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                         STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.09     HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00     ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....      15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........    10799.99     ESTIMATED GROUND REFLECTANCE...........        0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...      140.00     ESTIMATED PUMPING POWER(KWF/AREAC)......     1.0000
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...       20.00     ESTIMATED CORRECTION FOR TAU ALPHA PROD.       0.93
ESTIMATED DHW USERS (PER)...............        6.00     ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00     ESTIMATED HEX COST ($/FT**2) ..........        5.00
                                                         ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                         MAINTENANCE (% INSTALLED COST/YR).......     0.0010
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN    *
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*    RESULTS OF ANALYSIS FOR TULSA    OKLAHOMA      *
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                  >>>>>DATA MATCH TO INPUT ID NO. 15223
                               IMED-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.9792E 07	0.2637E 07	1486.3	1.639	0.210
FEB	978.0	681.3	40.9	0.7358E 07	0.2382E 07	1911.1	1.420	0.293
MAR	1306.0	513.7	48.8	0.5543E 07	0.2637E 07	2514.7	1.179	0.434
APR	1603.0	180.3	60.8	0.1947E 07	0.2552E 07	3126.9	0.986	0.683
MAY	1822.0	45.0	68.9	0.4860E 06	0.2637E 07	3560.5	0.872	0.854
JUN	2021.0	1.8	77.0	0.1944E 05	0.2552E 07	3744.0	0.823	0.945
JUL	2031.0	0.3	82.2	0.3240E 04	0.2637E 07	3660.4	0.844	0.974
AUG	1865.0	0.1	80.7	0.1080E 04	0.2637E 07	3309.3	0.939	0.982
SEP	1473.0	21.5	72.7	0.2322E 06	0.2552E 07	2747.3	1.105	0.902
OCT	1164.0	163.0	61.9	0.1760E 07	0.2637E 07	2105.7	1.356	0.706
NOV	827.4	490.8	48.8	0.5301E 07	0.2552E 07	1587.8	1.602	0.363
DEC	659.3	799.9	39.2	0.8639E 07	0.2637E 07	1359.5	1.716	0.212
TOTAL		3304.4		0.4109E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.461

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          DESIGN VARIABLES/CONSTRAINTS                                       OTHER PARAMETERS
          ----------------------------                                       ----------------
COLLECTOR AREA  (FT**2) ...............>>>      211.75  COLLECTOR SIDE CAPACITY (BTU/HR  F)..... 0.219E 04
COLLECTOR TILT ANGLE  (DEG) ...........>>>       41.00  STORAGE SIDE CAPACITY (BTU/HR  F)....... 0.392E 05
COLLECTOR SIDE TUBE INNER DIA. (FT) ....        0.0657  COLLECTOR SIDE CONVECTION COEFF......... 1060.6411
COLLECTOR SIDE TUBE OUTER DIA. (FT) ....        0.0717  STORAGE SIDE CONVECTION COEFFICIENT .... 3584.2903
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..        0.1312  COLLECTOR SIDE FLOW RATE  (GPM) ........    4.4805
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..        2.9484  STORAGE SIDE FLOW RATE  (GPM) ..........   78.6359
STORAGE SIDE FLUID VELOCITY  (FT/SEC) ..       18.4803  NORMALIZED COLLECTOR FLOW (GPM/AREAC)...    0.0212
HEAT EXCHANGER LENGTH (FT) .............         77.37  NORMALIZED STORAGE FLOW  (GPM/AREAC) ...    0.3714
///////////////CONSTRAINTS///////////////               HEAT EXCHANGER EFFECTIVENESS............    0.8905
HEX ANNULAR DIAMETER DIFFERENCE (FT)....        0.0595  SOLAR ENERGY DELIVERED (BTU/YEAR)....... 0.332E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).        0.0060  TOTAL ENERGY DEMAND  (BTU/YEAR) ........ 0.721E 08
COLLECTOR SIDE REYNOLDS NUMBER.......... 0.494E 05      ANNUAL AVERAGE SOLAR LOAD FRACTION .....    0.4608
STORAGE SIDE REYNOLDS NUMBER ........... 0.155E 06      OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>> 0.313E 04
CAPACITY RATIO (CMIN/CMAX)..............        0.0553  HEX COEFFICIENT (BTU/HR F FT**2)........    311.38
FLOW PARAMETER Z2(GCP/HPUL).............        9.9329  TOTAL INSTALLATION COST ($) ............   3844.03
FLOW PARAMETER Z1(GCP/FRPUL)............          9.42  COLLECTOR FLOW FACTOR(FPP)..............    0.9488
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*                                                   *
*                 S O L O A D - 1                   *
*                                                   *
*    SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN   *
*                                                   *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY         *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                 >>>>>DATA MATCH TO OUTPUT ID NO. 15232
                               INCD-1 LWK AUGUST 1979


LOCATION       TULSA   OKLAHOMA       COLLECTOR FEDERAL PRISM I. D          STUDY APPROACH        ANALYSIS
--------                              ---------                             --------------

LOCATION INDEX......            15    COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....         36.20      SLOPE:                              ------------------
MEAN TEMPERATURE....         59.81      PARAMETER,FRUL....      0.8830
INSOL(BTU/DAY FT**2)       1373.47      INTERCEPT:                          SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....       3804.40      PARAMETER,FRTA....      0.6270      DISCOUNT RATE ......      0.0900
MEAN GROUND TEMP....         55.00    BASE COST,$/FT**2...        9.40      INFLATION RATE......      0.1100


ENERGY COMPARATIVE ESTIMATES                                  SELECTED PARAMETERS
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TYPE ENERGY BASE.................................OIL          COLLECTOR FLUID MEAN TEMPERATURE........        176.00
INDEX TYPE EFFICIENCY    COST          HEATING VALUE          COLLECTOR FLUID DENSITY(LB/FT**3).......         60.81
  1    OIL    0.70   0.90($/GAL)  142000.0(BTU/GAL)           COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).        1.0000
  2    ELE    0.99   0.05($/KWH)    3413.0(BTU/KWH)           COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS    0.70   0.40($/THM)  100000.0(BTU/THM)           STORAGE FLUID MEAN TEMPERATURE ........         164.00
                                                              STORAGE FLUID DENSITY(LB/FT**3).........         62.09
HEAT LOAD CHARACTERISTICS                                     STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...        1.0000
-------------------------                                     STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).        0.3640
                                                              COLLECTOR SIDE FOULING FACTOR(HR F/BTU)         0.0010
                                                              STORAGE SIDE FOULING FACTOR(HR F/BTU)           0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.17         HEX TUBE CONDUCTIVITY(BTU/HR FT F)......        220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00         ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....         15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........     20399.99         ESTIMATED GROUND REFLECTANCE...........,          0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00         ESTIMATED PUMPING POWER(KWH/AREAC)......        1.0000
ESTIMATED DAILY DHW USAGE (GAL/PER) ...         20.00         ESTIMATED CORRECTION FOR TAU ALPHA PRED.          0.93
ESTIMATED DHW USERS (PER)...............         6.00         ESTIMATED INSTALL/LABOR COST ($/AREAC)..         10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00         ESTIMATED HEX COST ($/FT**2) ..........           5.00
                                                              ESTIMATED STORAGE TANK COST($/LB STORED)          0.09
                                                              MAINTENANCE (% INSTALLED COST/YR).......        0.0010
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*                 S O L O A D - 1                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN    *
*   ---                                             *
*      RESULTS OF ANALYSIS FOR TULSA   OKLAHOMA     *
*                                                   *
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                 >>>>>DATA MATCH TO INPUT ID NO. 15232
                             IMCD-1 LWK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	732.0	906.7	35.8	0.1850E 08	0.2637E 07	1486.3	1.659	0.146
FEB	976.0	681.3	40.9	0.1390E 08	0.2382E 07	1911.1	1.429	0.208
MAR	1306.0	513.7	48.8	0.1048E 08	0.2637E 07	2514.7	1.176	0.315
APR	1603.0	180.3	60.8	0.3673E 07	0.2552E 07	3126.9	0.973	0.581
MAY	1822.0	45.0	68.9	0.9180E 06	0.2637E 07	3560.5	0.853	0.842
JUN	2021.0	1.8	77.0	0.3672E 05	0.2552E 07	3744.0	0.802	0.978
JUL	2031.0	0.3	82.2	0.6120E 04	0.2637E 07	3660.4	0.824	1.000
AUG	1865.0	0.1	80.7	0.2040E 04	0.2637E 07	3309.3	0.923	1.000
SEP	1473.0	21.5	72.7	0.4386E 06	0.2552E 07	2747.3	1.057	0.925
OCT	1164.0	163.0	61.9	0.3325E 07	0.2637E 07	2105.7	1.361	0.624
NOV	827.4	490.8	48.8	0.1001E 08	0.2552E 07	1587.8	1.620	0.269
DEC	659.3	759.9	39.2	0.1632E 08	0.2637E 07	1359.5	1.740	0.150
TOTAL		3804.4		0.7761E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.347

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	222.35	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.191E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	43.64	STORAGE SIDE CAPACITY (BTU/HR F).......	0.326E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0568	COLLECTOR SIDE CONVECTION COEFF.........	1235.9021
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0618	STORAGE SIDE CONVECTION COEFFICIENT	3411.1859
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1208	COLLECTOR SIDE FLOW RATE (GPM)	3.9093
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.4420	STORAGE SIDE FLOW RATE (GPM)	65.3802
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	17.1980	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0176
HEAT EXCHANGER LENGTH (FT)	66.71	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2940
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.8581
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0591	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.377E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.109E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.498E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3473
STORAGE SIDE REYNOLDS NUMBER	0.143E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.329E 04
CAPACITY RATIO (CMIN/CMAX)..............	0.0586	HEX COEFFICIENT (BTU/HR F FT**2)........	323.69
FLOW PARAMETER Z2(SCP/FPUL).............	9.7116	TOTAL INSTALLATION COST ($)	4645.24
FLOW PARAMETER Z1(GCP/FPUL).............	9.20	COLLECTOR FLOW FACTOR(FRP)..............	0.9476

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*                 S O L O A D - 1                 *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
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*         DESIGN DATA OPTIONS/INPUTS SUMMARY      *
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                  >>>>>DATA MATCH TO OUTPUT ID NO. 16111
                                IMCD-1 LWK AUGUST 1979


LOCATION       NORFOLK VIRGINIA    COLLECTOR SOLARNETICS                STUDY APPROACH        ANALYSIS
--------                           ---------                            --------------

LOCATION INDEX......         16    COLLECTOR TEST RESULTS,              ECONOMIC ESTIMATES
LATITUDE,DEGREES....      36.90      SLOPE:                             ------------------
MEAN TEMPERATURE....      59.22      PARAMETER,FRUL....      1.0380
INSOL(BTU/DAY FT**2)    1325.29      INTERCEPT:                         SYSTEM LIFE(YEARS)..      20.00
LOAD FACTOR,HDD.....    3510.50      PARAMETER,FRTA....      0.6910     DISCOUNT RATE ......     0.1150
MEAN GROUND TEMP....      55.00    BASE COST,$/FT**2...       12.98     INFLATION RATE......     0.1050


ENERGY COMPARATIVE ESTIMATES                                  SELECTED PARAMETERS
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TYPE ENERGY BASE............................          OIL     COLLECTOR FLUID MEAN TEMPERATURE........       176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE           COLLECTOR FLUID DENSITY(LB/FT**3).......        60.81
  1    OIL     0.70    0.90($/GAL) 142000.0(BTU/GAL)          COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).       1.0000
  2    ELE     0.99    0.05($/KWH)   3413.0(BTU/KWH)          COLLECTOR FL'D CONDUCTIVITY(BTU/HR*FT*F)       0.3870
  3    GAS     0.70    0.40($/THM) 100000.0(BTU/THM)          STORAGE FLUID MEAN TEMPERATURE ........        104.00
                                                              STORAGE FLUID DENSITY(LB/FT**3).........        62.09
HEAT LOAD CHARACTERISTICS                                     STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...       1.0000
-------------------------                                     STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).       0.3640
                                                              COLLECTOR SIDE FOULING FACTOR(HR F/BTU)        0.0010
                                                              STORAGE SIDE FOULING FACTOR(HR F/BTU)          0.0010
                                                              HEX TUBE CONDUCTIVITY(BTU/HR FT F)......       220.00
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..           0.25       ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....        15.30
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..        5000.00       ESTIMATED GROUND REFLECTANCE...........,         0.20
LOAD CONDUCTANCE (BTU/DEG F DAY)........       30000.00       ESTIMATED PUMPING POWER(KWH/AREAC)......       1.0000
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...         140.00       ESTIMATED CORRECTION FOR TAU ALPHA PRED.         0.93
ESTIMATED DAILY DHW USAGE (GAL/PER) ...           20.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..        10.00
ESTIMATED DHW USERS (PER)..............            6.00       ESTIMATED HEX COST ($/FT**2) ...........         5.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.           1.00       ESTIMATED STORAGE TANK COST($/LB STORED)         0.08
                                                              MAINTENANCE (% INSTALLED COST/YR).......         0.01
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S O L O A C - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA

>>>>>DATA MATCH TO INPUT ID NO. 16111
DMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.2293E 08	0.2637E 07	1450.2	1.588	0.051
FEB	931.4	655.4	41.8	0.1966E 08	0.2382E 07	1878.0	1.400	0.072
MAR	1281.0	527.5	48.1	0.1583E 08	0.2637E 07	2489.0	1.188	0.118
APR	1676.7	248.0	57.9	0.7440E 07	0.2552E 07	3112.7	1.016	0.239
MAY	1887.5	71.7	66.2	0.2151E 07	0.2637E 07	3557.7	0.909	0.472
JUN	2000.3	4.9	74.1	0.1470E 06	0.2552E 07	3747.1	0.865	0.713
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.886	0.710
AUG	1680.2	0.1	76.7	0.3000E 04	0.2637E 07	3299.5	0.968	0.702
SEP	1395.6	10.1	71.5	0.3030E 06	0.2552E 07	2725.4	1.116	0.619
OCT	1083.0	153.5	61.2	0.4605E 07	0.2637E 07	2074.7	1.335	0.271
NOV	811.2	403.0	51.8	0.1209E 08	0.2552E 07	1552.3	1.578	0.114
DEC	623.8	671.9	43.3	0.2016E 08	0.2637E 07	1323.0	1.668	0.055
TOTAL		3510.5		0.1053E 09	0.3105E 08			

>>>WEIGHTED AVERAGE 0.161

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	100.00	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.991E 03
COLLECTOR TILT ANGLE (DEG) ....>>>	35.79	STORAGE SIDE CAPACITY (BTU/HR F).......	0.447E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0426	COLLECTOR SIDE CONVECTION COEFF.........	1226.7756
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0526	STORAGE SIDE CONVECTION COEFFICIENT	3802.4253
STORAGE SIDE TUBE(HLX) INNER DIA. (FT)..	0.1246	COLLECTOR SIDE FLOW RATE (GPM)	2.0309
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.1742	STORAGE SIDE FLOW RATE (GPM)	89.6943
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.9255	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0203
HEAT EXCHANGER LENGTH (FT)	65.36	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.8969
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9424
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0720	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.220E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100	TOTAL ENERGY DEMAND (BTU/YEAR)	0.136E 09
COLLECTOR SIDE REYNOLDS NUMBER...........	0.345E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.1614
STORAGE SIDE REYNOLDS NUMBER	0.203E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.626E 03
CAPACITY RATIO (CMIN/CMAX).............	0.0222	HEX COEFFICIENT (BTU/HR F FT**2)........	328.02
FLOW PARAMETER Z2(GCP/FRUL)............	9.5433	TOTAL INSTALLATION COST ($)	3004.16
FLOW PARAMETER Z1(GCP/FRPUL)...........	9.03	COLLECTOR FLOW FACTOR(FRP)..............	0.9466

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*                  S O L D A C - 1                    *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN      *
*       DESIGN DATA OPTIONS/INPUTS SUMMARY            *
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                    >>>>>DATA MATCH TO OUTPUT ID NO. 16112
                                  IMOD-1 LWK AUGUST 1975

LOCATION        NORFOLK VIRGINIA     COLLECTOR SOLARNETICS                        STUDY APPROACH          ANALYSIS

LOCATION INDEX......         16     COLLECTOR TEST RESULTS,                       ECONOMIC ESTIMATES
LATITUDE,DEGREES....      36.90       SLOPE:
MEAN TEMPERATURE....      59.22       PARAMETER,FRUL....        1.0380
INSOL(BTU/DAY FT**2)    1325.29       INTERCEPT:                                 SYSTEM LIFE(YEARS)..       20.00
LOAD FACTOR,FDC.....    3510.50       PARAMETER,ETA....         0.6910           DISCOUNT RATE ......       0.1150
MEAN GROUND TEMP....      55.00     BASE COST,$/FT**2...        12.98            INFLATION RATE......       0.1050

ENERGY COMPARATIVE ESTIMATES                                    SELECTED PARAMETERS

TYPE ENERGY BASE..............................OIL              COLLECTOR FLUID MEAN TEMPERATURE........         176.00
INDEX TYPE EFFICIENCY   COST          HEATING VALUE             COLLECTOR FLUID DENSITY(LB/FT**3)........         60.81
  1    OIL    0.70   0.90($/GAL) 142000.0(BTU/GAL)              COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).          1.0000
  2    ELE    0.99   0.05($/KWH)   3413.0(BTU/KWH)              COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)         0.3870
  3    GAS    0.70   0.40($/THM) 100000.0(BTU/THM)              STORAGE FLUID MEAN TEMPERATURE ........          104.00
                                                                STORAGE FLUID DENSITY(LB/FT**3).........           62.09
HEAT LOAD CHARACTERISTICS                                       STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...          1.0000
                                                                STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).          0.3640
                                                                COLLECTOR SIDE FOULING FACTOR(HR F/BTU)           0.0010
                                                                STORAGE SIDE FOULING FACTOR(HR F/BTU)             0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..         0.17           HEX TUBE CONDUCTIVITY(BTU/HR FT F)......         220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..      5000.00           ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....          15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........     20399.99           ESTIMATED GROUND REFLECTANCE...........,           0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...       140.00           ESTIMATED PUMPING POWER(KWH/AREAC)......          1.0000
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...        20.00           ESTIMATED CORRECTION FOR TAU ALPHA PROD.           0.93
ESTIMATED DHW USERS (PER)...............         6.00           ESTIMATED INSTALL/LABOR COST ($/AREAC)..          10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.         1.00           ESTIMATED HEX COST ($/FT**2) ...........           5.00
                                                                ESTIMATED STORAGE TANK COST($/LB STORED)           0.08
                                                                MAINTENANCE (% INSTALLED COST/YR).......           0.01
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*              S O L O A D - 1                  *
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*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
*                                               *
*    RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA   *
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>>>>>DATA MATCH TO INPUT ID NO. 16112
OMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.1559E 08	0.2637E 07	1450.2	1.582	0.071
FEB	931.4	655.4	41.8	0.1337E 08	0.2382E 07	1878.0	1.357	0.099
MAR	1281.0	527.5	48.1	0.1076E 08	0.2637E 07	2489.0	1.188	0.160
APR	1676.7	248.0	57.9	0.5059E 07	0.2552E 07	3112.7	1.018	0.305
MAY	1887.5	71.7	66.2	0.1463E 07	0.2637E 07	3557.7	0.912	0.535
JUN	2000.3	4.9	74.1	0.9996E 05	0.2552E 07	3747.1	0.869	0.724
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.889	0.713
AUG	1680.2	0.1	76.7	0.2040E 04	0.2637E 07	3299.5	0.971	0.704
SEP	1395.0	10.1	71.5	0.2060E 06	0.2552E 07	2725.4	1.117	0.634
OCT	1083.0	153.5	61.2	0.3131E 07	0.2637E 07	2074.7	1.333	0.329
NOV	811.2	403.0	51.8	0.8221E 07	0.2552E 07	1552.3	1.572	0.152
DEC	623.8	671.9	43.3	0.1371E 08	0.2637E 07	1323.0	1.661	0.075
TOTAL		3510.5		0.7161E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.211

DESIGN VARIABLES/CONSTRAINTS

COLLECTOR AREA (FT**2) ....>>>	100.00
COLLECTOR TILT ANGLE (DEG) ....>>>	35.24
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0447
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0547
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1346
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	2.8701
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	21.6572
HEAT EXCHANGER LENGTH (FT)	66.28
///////////////CONSTRAINTS///////////////	
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0799
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0100
COLLECTOR SIDE REYNOLDS NUMBER..........	0.327E 05
STORAGE SIDE REYNOLDS NUMBER	0.244E 06
CAPACITY RATIO (CMIN/CMAX).............	0.0172
FLOW PARAMETER Z2(GCP/FRUL)............	9.5092
FLOW PARAMETER Z1(GCP/F'PUL)...........	9.00

OTHER PARAMETERS

COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.987E 03
STORAGE SIDE CAPACITY (BTU/HR F).......	0.575E 05
COLLECTOR SIDE CONVECTION COEFF.........	1120.8818
STORAGE SIDE CONVECTION COEFFICIENT	4014.7375
COLLECTOR SIDE FLOW RATE (GPM)	2.0237
STORAGE SIDE FLOW RATE (GPM)	115.4498
NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0202
NORMALIZED STORAGE FLOW (GPM/AREAC) ...	1.1545
HEAT EXCHANGER EFFECTIVENESS............	0.9498
SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.217E 08
TOTAL ENERGY DEMAND (BTU/YEAR)	0.103E 09
ANNUAL AVERAGE SOLAR LOAD FRACTION	0.2111
OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.569E 03
HEX COEFFICIENT (BTU/HR F FT**2)........	320.90
TOTAL INSTALLATION COST ($)	3007.50
COLLECTOR FLOW FACTOR(FPP).............	0.9464

```
S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 16222
IMCD-1 LWK AUGUST 1979
```

```
LOCATION            NORFOLK VIRGINIA
--------

LOCATION INDEX......                16
LATITUDE,DEGREES....             36.90
MEAN TEMPERATURE....             59.22
INSOL(BTU/DAY FT**2)           1325.29
LOAD FACTOR,HDD.....           3510.50
MEAN GROUND TEMP....             55.00
```

```
COLLECTOR AMERICAN SUN
---------

COLLECTOR TEST RESULTS,
   SLOPE:
   PARAMETER,FRUL....     1.0390
   INTERCEPT:
   PARAMETER,FRTA....     0.6380
BASE COST,$/FT**2...        6.55
```

```
STUDY APPROACH                 ANALYSIS
--------------

ECONOMIC ESTIMATES
------------------

SYSTEM LIFE(YEARS)..              20.00
DISCOUNT RATE ......             0.0900
INFLATION RATE......             0.1100
```

```
ENERGY COMPARATIVE ESTIMATES
----------------------------

TYPE ENERGY BASE..............................       OIL
INDEX TYPE EFFICIENCY   COST          HEATING VALUE
  1    OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)
  3    GAS     0.70   0.40($/THM)  100000.0(BTU/THM)
```

```
HEAT LOAD CHARACTERISTICS
-------------------------

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..          0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..       5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........      20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...        140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...         30.00
ESTIMATED DHW USERS (PER)...............          6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.          1.00
```

```
SELECTED PARAMETERS
-------------------

COLLECTOR FLUID MEAN TEMPERATURE.........            176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......              60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).             1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)            0.3870
STORAGE FLUID MEAN TEMPERATURE .........            104.00
STORAGE FLUID DENSITY(LB/FT**3).........              62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...             1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).             0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)              0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)                0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......            220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....              15.30
ESTIMATED GROUND REFLECTANCE............               0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......             1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PROD.               0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..              10.00
ESTIMATED HEX COST ($/FT**2) ...........               5.00
ESTIMATED STORAGE TANK COST($/LB STORED)               0.08
MAINTENANCE (% INSTALLED COST/YR).......             0.0010
```

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*                                                   *
*               S O L O A D - 1                     *
*                                                   *
*    SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN   *
*    ---          -            -          -         *
*     RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA      *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * *
                    >>>>>DATA MATCH TO INPUT ID NO. 16222
                                 MOD-1 LWK AUGUST 1979
```

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.1559E 08	0.2637E 07	1450.2	1.645	0.162
FEB	931.4	655.4	41.8	0.1337E 08	0.2382E 07	1878.0	1.429	0.219
MAR	1281.0	527.5	48.1	0.1076E 08	0.2637E 07	2489.0	1.186	0.335
APR	1676.7	248.0	57.9	0.5059E 07	0.2552E 07	3112.7	0.989	0.575
MAY	1887.5	71.7	66.2	0.1463E 07	0.2637E 07	3557.7	0.868	0.842
JUN	2000.3	4.9	74.1	0.9996E 05	0.2552E 07	3747.1	0.819	0.965
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.843	0.958
AUG	1680.2	0.1	76.7	0.2040E 04	0.2637E 07	3299.5	0.935	0.958
SEP	1395.6	10.1	71.5	0.2060E 06	0.2552E 07	2725.4	1.104	0.923
OCT	1083.0	153.5	61.2	0.3131E 07	0.2637E 07	2074.7	1.355	0.628
NOV	811.2	403.0	51.8	0.8221E 07	0.2552E 07	1552.3	1.632	0.332
DEC	623.8	671.9	43.3	0.1371E 08	0.2637E 07	1323.0	1.737	0.172
TOTAL		3510.5		0.7161E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.379

```
      DESIGN VARIABLES/CONSTRAINTS                                      OTHER PARAMETERS
      ----------------------------                                      ----------------
COLLECTOR AREA  (FT**2) ...............>>>    260.32  COLLECTOR SIDE CAPACITY (BTU/HR  F)..... 0.262E 04
COLLECTOR TILT ANGLE  (DEG) ...........>>>     42.13  STORAGE SIDE CAPACITY (BTU/HR  F)....... 0.384E 05
COLLECTOR SIDE TUBE INNER DIA. (FT) ....      0.0695  COLLECTOR SIDE CONVECTION COEFF......... 1107.4634
COLLECTOR SIDE TUBE OUTER DIA. (FT) ....      0.0745  STORAGE SIDE CONVECTION COEFFICIENT .... 3578.6917
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..      0.1321  COLLECTOR SIDE FLOW RATE  (GPM) ........    5.3669
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..      3.1561  STORAGE SIDE FLOW RATE  (GPM) ..........   77.1474
STORAGE SIDE FLUID VELOCITY  (FT/SEC) ..     18.3892  NORMALIZED COLLECTOR FLOW (GPM/AREAC)...    0.0206
HEAT EXCHANGER LENGTH (FT) .............       69.90  NORMALIZED STORAGE FLOW  (GPM/AREAC) ...    0.2964
///////////////CONSTRAINTS//////////////              HEAT EXCHANGER EFFECTIVENESS............    0.8294
HEX ANNULAR DIAMETER DIFFERENCE (FT)....      0.0576  SOLAR ENERGY DELIVERED (BTU/YEAR)....... 0.389E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).      0.0050  TOTAL ENERGY DEMAND  (BTU/YEAR) ........ 0.103E 09
COLLECTOR SIDE REYNOLDS NUMBER.......... 0.559E 05    ANNUAL AVERAGE SOLAR LOAD FRACTION .....    0.3787
STORAGE SIDE REYNOLDS NUMBER .......... 0.150E 06     OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>> 0.343E 04
CAPACITY RATIO (C1IN/CMAX)..............      0.0681  HEX COEFFICIENT (BTU/HR F FT**2)........    315.00
FLOW PARAMETER Z2(GCP/FRUL).............      9.6783  TOTAL INSTALLATION COST ($) ............   4703.12
FLOW PARAMETER Z1(GCP/FPPUL)............        9.17  COLLECTOR FLOW FACTOR(FPP)..............    0.9474
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*                                               *
*               S O L I A D - 1                 *
*                                               *
*  SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN *
*                                               *
*       DESIGN DATA OPTIONS/INPUTS SUMMARY      *
*                                               *
* * * * * * * * * * * * * * * * * * * * * * * * *
                >>>>>DATA MATCH TO OUTPUT ID NO. 16223
                          IMOD-1 LWK AUGUST 1979
```

LOCATION NORFOLK VIRGINIA

LOCATION INDEX......	16
LATITUDE,DEGREES....	36.90
MEAN TEMPERATURE....	59.22
INSOL(BTU/DAY FT**2)	1325.29
LOAD FACTOR,HLD.....	3510.50
MEAN GROUND TEMP....	55.00

COLLECTOR AMERICAN SUN

COLLECTOR TEST RESULTS,	
SLOPE:	
PARAMETER,FRUL	1.0390
INTERCEPT:	
PARAMETER,FRTA....	0.6380
BASE COST,$/FT**2...	6.55

STUDY APPROACH ANALYSIS

ECONOMIC ESTIMATES

SYSTEM LIFE(YEARS)..	20.00
DISCOUNT RATE	0.0900
INFLATION RATE......	0.1100

ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE............................ OIL

INDEX	TYPE	EFFICIENCY	COST	HEATING VALUE
1	OIL	0.70	0.90($/GAL)	142000.0(BTU/GAL)
2	ELE	0.99	0.05($/KWH)	3413.0(BTU/KWH)
3	GAS	0.70	0.40($/THM)	100000.0(BTU/THM)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..	0.09
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..	5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........	10799.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...	140.00
ESTIMATED DAILY DHW USAGE (GAL/PER) ...	20.00
ESTIMATED DHW USERS (PER).............	6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.	1.00

SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........	176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......	60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).	1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)	0.3870
STORAGE FLUID MEAN TEMPERATURE	104.00
STORAGE FLUID DENSITY(LB/FT**3).........	62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...	1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).	0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)	0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)	0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......	220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC)	15.30
ESTIMATED GROUND REFLECTANCE............	0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......	1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.	0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..	10.00
ESTIMATED HEX COST ($/FT**2)	5.00
ESTIMATED STORAGE TANK COST($/LB STORED)	0.08
MAINTENANCE (% INSTALLED COST/YR).......	0.0010

S O L O A D - 1

SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN

RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA

>>>>>DATA MATCH TO INPUT ID NO. 16223
IMOD-1 LWK AUGUST 1979

MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.8256E 07	0.2637E 07	1450.2	1.628	0.206
FEB	931.4	655.4	41.8	0.7078E 07	0.2382E 07	1878.0	1.421	0.279
MAR	1281.0	527.5	48.1	0.5697E 07	0.2637E 07	2489.0	1.188	0.410
APR	1676.7	248.0	57.9	0.2678E 07	0.2552E 07	3112.7	0.959	0.640
MAY	1887.5	71.7	66.2	0.7744E 06	0.2637E 07	3557.7	0.882	0.836
JUN	2000.3	4.9	74.1	0.5292E 05	0.2552E 07	3747.1	0.835	0.929
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.858	0.915
AUG	1680.2	0.1	76.7	0.1080E 04	0.2637E 07	3299.5	0.947	0.913
SEP	1395.6	10.1	71.5	0.1091E 06	0.2552E 07	2725.4	1.109	0.874
OCT	1083.0	153.5	61.2	0.1658E 07	0.2637E 07	2074.7	1.350	0.652
NOV	811.2	403.0	51.8	0.4352E 07	0.2552E 07	1552.3	1.616	0.390
DEC	623.8	671.9	43.3	0.7257E 07	0.2637E 07	1323.0	1.716	0.216
TOTAL		3510.5		0.3791E 08	0.3105E 08			

>>>WEIGHTED AVERAGE 0.460

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	207.96	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.208E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	40.03	STORAGE SIDE CAPACITY (BTU/HR F).......	0.304E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0567	COLLECTOR SIDE CONVECTION COEFF.........	1328.5417
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0617	STORAGE SIDE CONVECTION COEFFICIENT	3318.2532
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1194	COLLECTOR SIDE FLOW RATE (GPM)	4.2714
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.7667	STORAGE SIDE FLOW RATE (GPM)	60.9549
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	16.5528	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0205
HEAT EXCHANGER LENGTH (FT)	58.21	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.2931
///////////////CONSTRAINTS///////////////		HEAT EXCHANGER EFFECTIVENESS............	0.7943
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0577	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.317E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0050	TOTAL ENERGY DEMAND (BTU/YEAR)	0.690E 08
COLLECTOR SIDE REYNOLDS NUMBER...........	0.545E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.4596
STORAGE SIDE REYNOLDS NUMBER	0.135E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.289E 04
CAPACITY RATIO (CMIN/CMAX)...............	0.0686	HEX COEFFICIENT (BTU/HR F FT**2)........	328.89
FLOW PARAMETER Z2(GCP/FRUL).............	9.6419	TOTAL INSTALLATION COST ($)	3748.17
FLOW PARAMETER Z1(GCP/FRPUL)............	9.13	COLLECTOR FLOW FACTOR(FPP)...............	0.9472

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S O L C A D - I
SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN
DESIGN DATA OPTIONS/INPUTS SUMMARY

>>>>>DATA MATCH TO OUTPUT ID NO. 16232
IMOD-I LWK AUGUST 1979
```

```
LOCATION         NORFOLK VIRGINIA      COLLECTOR FEDERAL PRISON I. D          STUDY APPROACH             ANALYSIS

LOCATION INDEX......           16      COLLECTOR TEST RESULTS,                ECONOMIC ESTIMATES
LATITUDE,DEGREES....        36.90        SLOPE:
MEAN TEMPERATURE....        59.22        PARAMETER,FRUL ....      0.8830
INSOL(BTU/DAY FT**2)      1325.29        INTERCEPT:                           SYSTEM LIFE(YEARS)..          20.00
LOAD FACTOR,HDD.....      3510.50        PARAMETER,FRTA....       0.6270      DISCOUNT RATE ......         0.0900
MEAN GROUND TEMP....        55.00      BASE COST,$/FT**2...         9.40      INFLATION RATE......         0.1100
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ENERGY COMPARATIVE ESTIMATES

TYPE ENERGY BASE......................................OIL
INDEX TYPE EFFICIENCY    COST           HEATING VALUE
  1    OIL     0.70   0.90($/GAL)  142000.0(BTU/GAL)
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)
  3    GAS     0.70   0.40($/TH)   100000.0(BTU/TH)

HEAT LOAD CHARACTERISTICS

LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..              0.17
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..           5000.00
LOAD CONDUCTANCE (BTU/DEG F DAY)........          20399.99
DOMESTIC HOT WATER(DHW) DESIGN TEMP. ...            140.00
ESTIMATED DAILY DHW USEAGE (GAL/PER) ...             20.00
ESTIMATED DHW USERS (PER)...............              6.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.              1.00
```

```
SELECTED PARAMETERS

COLLECTOR FLUID MEAN TEMPERATURE........            176.00
COLLECTOR FLUID DENSITY(LB/FT**3).......             60.81
COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).            1.0000
COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)           0.3870
STORAGE FLUID MEAN TEMPERATURE ........             104.00
STORAGE FLUID DENSITY(LB/FT**3).........             62.09
STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...            1.0000
STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).            0.3640
COLLECTOR SIDE FOULING FACTOR(HR F/BTU)             0.0010
STORAGE SIDE FOULING FACTOR(HR F/BTU)               0.0010
HEX TUBE CONDUCTIVITY(BTU/HR FT F)......            220.00
ESTIMATED OPTIMUM STORAGE(LB/AREAC) ....             15.30
ESTIMATED GROUND REFLECTANCE...........,              0.20
ESTIMATED PUMPING POWER(KWH/AREAC)......            1.0000
ESTIMATED CORRECTION FOR TAU ALPHA PRED.              0.93
ESTIMATED INSTALL/LABOR COST ($/AREAC)..             10.00
ESTIMATED HEX COST ($/FT**2) ...........              5.00
ESTIMATED STORAGE TANK COST($/LB STORED)              0.04
MAINTENANCE (% INSTALLED COST/YR).......            0.0010
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*                 S I L O A D - I                   *
*                                                   *
*   SOLAR ENERGY OPTIMIZATION ANALYSIS OF DESIGN    *
*   ---          -            -        -            *
*     RESULTS OF ANALYSIS FOR NORFOLK VIRGINIA      *
*                                                   *
* * * * * * * * * * * * * * * * * * * * * * * * * * *
                  >>>>>DATA MATCH TO INPUT ID NO. 16232
                                 OMCD-1 LVK AUGUST 1979
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MONTH	HORIZONTAL INSOLATION	HEATING DEGREE DAYS	AMBIENT TEMPERATURE	HEATING LOAD	DHW LOAD	EXTRA-TERRESTRIAL INSOLATION	COLLECTOR TILT FACTOR	SOLAR ENERGY FRACTION
	BTU/DAY FT**2	DEG DAY	DEG F	BTU/MONTH	BTU/MONTH	BTU/DAY FT**2		
JAN	679.6	764.4	40.3	0.1559E 08	0.2637E 07	1450.2	1.634	0.162
FEB	931.4	655.4	41.8	0.1337E 08	0.2382E 07	1878.0	1.423	0.216
MAR	1281.0	527.5	48.1	0.1076E 08	0.2637E 07	2485.0	1.187	0.329
APR	1676.7	248.0	57.9	0.5059E 07	0.2552E 07	3112.7	0.996	0.570
MAY	1887.5	71.7	66.2	0.1463E 07	0.2637E 07	3557.7	0.877	0.856
JUN	2000.3	4.9	74.1	0.9996E 05	0.2552E 07	3747.1	0.830	0.998
JUL	1853.2	0.0	77.7	0.0	0.2637E 07	3660.7	0.853	0.990
AUG	1680.2	0.1	76.7	0.2040E 04	0.2637E 07	3299.5	0.943	0.989
SEP	1395.6	10.1	71.5	0.2060E 06	0.2552E 07	2725.4	1.107	0.946
OCT	1083.0	153.5	61.2	0.3131E 07	0.2637E 07	2074.7	1.351	0.624
NOV	811.2	403.0	51.8	0.8221E 07	0.2552E 07	1552.3	1.622	0.326
DEC	623.8	671.9	43.3	0.1371E 08	0.2637E 07	1323.0	1.723	0.172
TOTAL		3510.5		0.7161E 08	0.3105E 08			
						>>>WEIGHTED AVERAGE		0.380

DESIGN VARIABLES/CONSTRAINTS		OTHER PARAMETERS	
COLLECTOR AREA (FT**2) ....>>>	240.53	COLLECTOR SIDE CAPACITY (BTU/HR F).....	0.2091E 04
COLLECTOR TILT ANGLE (DEG) ....>>>	40.73	STORAGE SIDE CAPACITY (BTU/HR F).......	0.461E 05
COLLECTOR SIDE TUBE INNER DIA. (FT)	0.0616	COLLECTOR SIDE CONVECTION COEFF.........	1147.2280
COLLECTOR SIDE TUBE OUTER DIA. (FT)	0.0684	STORAGE SIDE CONVECTION COEFFICIENT	3732.0232
STORAGE SIDE TUBE(HEX) INNER DIA. (FT)..	0.1342	COLLECTOR SIDE FLOW RATE (GPM)	4.2888
COLLECTOR SIDE FLUID VELOCITY (FT/SEC)..	3.2015	STORAGE SIDE FLOW RATE (GPM)	92.5111
STORAGE SIDE FLUID VELOCITY (FT/SEC) ..	19.6708	NORMALIZED COLLECTOR FLOW (GPM/AREAC)...	0.0178
HEAT EXCHANGER LENGTH (FT)	85.67	NORMALIZED STORAGE FLOW (GPM/AREAC) ...	0.3846
///////////////CONSTRAINTS//////////////		HEAT EXCHANGER EFFECTIVENESS............	0.9148
HEX ANNULAR DIAMETER DIFFERENCE (FT)....	0.0659	SOLAR ENERGY DELIVERED (BTU/YEAR).......	0.390E 08
COLLECTOR SIDE TUBE DIA. DIFFERENCE(FT).	0.0067	TOTAL ENERGY DEMAND (BTU/YEAR)	0.103E 09
COLLECTOR SIDE REYNOLDS NUMBER..........	0.503E 05	ANNUAL AVERAGE SOLAR LOAD FRACTION	0.3800
STORAGE SIDE REYNOLDS NUMBER	0.183E 06	OBJECTIVE: NPV OF SOLAR INVESTMENT ..>>>	0.314E 04
CAPACITY RATIO (CMIN/CMAX).............	0.0454	HEX COEFFICIENT (BTU/HR F FT**2)........	319.71
FLOW PARAMETER Z2(GCP/FUL)..............	9.8493	TOTAL INSTALLATION COST ($)	5043.61
FLOW PARAMETER Z1(GCP/FRPUL)............	9.34	COLLECTOR FLOW FACTOR(FPP)..............	0.9433

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*                 S O L O A D - 1                 *
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*   SOLAR ENERGY OPTIMIZATION ANALYSIS OR DESIGN  *
*                                                 *
*        DESIGN DATA OPTIONS/INPUTS SUMMARY       *
*                                                 *
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              >>>>>DATA MATCH TO OUTPUT ID NO. 14232
                             IMOD-1 LWK AUGUST 1979

LOCATION       FRESNO      CALIF     COLLECTOR FEDERAL FRESNO 1. 0         STUDY APPROACH          ANALYSIS
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LOCATION INDEX......          14     COLLECTOR TEST RESULTS,               ECONOMIC ESTIMATES
LATITUDE,DEGREES....       36.77       SLOPE:                              ------------------
MEAN TEMPERATURE....       61.85        PARAMETER,FRUL ....    0.8830
INSOL(BTU/DAY FT**2)     1710.81        INTERCEPT:                         SYSTEM LIFE(YEARS)..        20.00
LOAD FACTOR,HDD.....     2826.40        PARAMETER,FRTA....     0.6270      DISCOUNT RATE ......       0.0900
MEAN GROUND TEMP....       55.00     BASE COST,$/FT**2...        9.40      INFLATION RATE......       0.1100

ENERGY COMPARATIVE ESTIMATES                               SELECTED PARAMETERS
----------------------------                               -------------------

TYPE ENERGY BASE..............................   OIL       COLLECTOR FLUID MEAN TEMPERATURE........     170.00
INDEX TYPE EFFICIENCY   COST         HEATING VALUE         COLLECTOR FLUID DENSITY(LB/FT**3).......      60.81
  1    OIL     0.70   0.90($/GAL ) 142000.0(BTU/GAL)       COLLECTOR FLUID SPECIFIC HEAT(BTU/LB*F).     1.0000
  2    ELE     0.99   0.05($/KWH)    3413.0(BTU/KWH)       COLLECTOR FLUID CONDUCTIVITY(BTU/HR*FT*F)    0.3870
  3    GAS     0.70   0.40($/THM) 100000.0(BTU/THM)        STORAGE FLUID MEAN TEMPERATURE ........     104.00
                                                           STORAGE FLUID DENSITY(LB/FT**3).........      62.09
HEAT LOAD CHARACTERISTICS                                  STORAGE FLUID SPECIFIC HEAT(BTU/LB*F)...     1.0000
-------------------------                                  STORAGE FLUID CONDUCTIVITY(BTU/HR FT F).     0.3640
                                                           COLLECTOR SIDE FOULING FACTOR(HR F/BTU)      0.0010
                                                           STORAGE SIDE FOULING FACTOR(HR F/BTU)        0.0010
LOAD LOSS COEFFICIENT (BTU/HR F FT**2)..        0.17       HEX TUBE CONDUCTIVITY(BTU/HR FT F)......     220.00
LOAD SURFACE HEAT TRANSFER AREA(FT**2)..     5000.00       ESTIMATED OPTIMUM STORAGE(LB/AREA )  ....      15.30
LOAD CONDUCTANCE (BTU/DEG F DAY)........    20390.00       ESTIMATED GROUND REFLECTANCE...........,       0.20
DOMESTIC HOT WATER(DHW) DESIGN TEMP.  ...     140.00       ESTIMATED PUMPING POWER(KWH/AREAC)......     1.0000
ESTIMATED DAILY DHW USAGE (GAL/PER) ...        20.00       ESTIMATED CORRECTION FOR TAU ALPHA PROD.       0.93
ESTIMATED DHW USERS (PER)...............        6.00       ESTIMATED INSTALL/LABOR COST ($/AREAC)..      10.00
ESTIMATED STORAGE TO LOAD EFFECTIVENESS.        1.00       ESTIMATED HEX COST ($/FT**2) ..........        5.00
                                                           ESTIMATED STORAGE TANK COST($/LB STORED)       0.08
                                                           MAINTENANCE (% INSTALLED COST/YR).......     0.0010
```

APPENDIX E

POTENTIAL CORRELATION FOR OPTIMUM COLLECTOR FLOW RATE

Reference [2] defines the collector heat removal factor, F_r, as:

$$F_r = \frac{Gc_p}{U_L} \{1 - \exp(\frac{-F'U_L}{Gc_p})\} \quad \text{(B1)}$$

Further, the collector flow factor, F", is defined as,

$$F'' = \frac{F_r}{F'} = \frac{Gc_p}{F'U_L} \{1 - \exp(\frac{-F'U_L}{Gc_p})\} \quad \text{(B2)}$$

Reference [2] shows that F" approaches the unity value asymptotically as the parameter Gc_p/U_LF' increases. Reference [3] recommends capacity rates of 10-15 lb/hr ft_c^2 (.0223 - .0334 Gpm/ft_c^2) as the best compromise among collector heat transfer coefficient, fluid pressure drop, and energy delivery. The unit ft_c refers to collector area.

The results of this thesis suggested a correlation between the collector performance parameter F_rU_L and the capacity rate. Once these results are verified by further testing including model changes to include fluid pressure drop, a simple correlation may be available and follows from:

Let, κ^* = The optimum flow factor determined from computer experiments.

$\zeta_1 = Gc_p/F'U_L$

$\zeta_2 = Gc_p/F_rU_L$

It follows from equations (B1) and (B2) that:

$$F'' = \frac{1}{\zeta_2}$$

$$\frac{1}{\zeta_2} = 1 - \exp(-1/\zeta_1)$$

or,

$$\zeta_1 = \frac{1}{-\ln(1 - 1/\zeta_2)}$$

Let, ζ_1^* = The optimum parameter which corresponds to κ^* and is obtained by solving equation (B2) for ζ_1

Therefore,

$$\kappa^* = \frac{\zeta_1^*}{\zeta_2}$$

or

$$\zeta_2 = \frac{\zeta_1^*}{\kappa^*}$$

or

$$Gc_p/F_rU_L = \frac{\zeta_1^*}{\kappa^*}$$

or,

$$G = \frac{\zeta_1^*}{\kappa^*} F_r U_L / c_p$$

or,

$$G = \kappa^{**} F_r U_L$$

Based on the results of a limited number of computer experiments all yielding an apparent invarient flow factor, F" = .948:

$$\kappa^{**} = .01955 \text{ (Gpm hr F/Btu)}$$

Or,

$$G = .01955 F_r U_L \quad (\text{Gpm/ft}_c^2)$$

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